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We would also like to acknowledge the valuable assistance of the Scientific Authorities, Rick Hurst (INAC) and Bill Brakel (Environment Canada). Overall project management was the responsibility of David Thomas.

The collective effort of all study team members in preparation of BREAM Project Overviews is gratefully acknowledged.

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Wayne Duval was responsible for preparation of Sections 3 and 4 of this report, which describe the results of the planning meeting and information database workshop, respectively. The current hydrocarbon development scenario for the Beaufort region (Section 2) was prepared by Patricia Vonk of ESL. Ms. Vonk was also responsible for editing and reformatting of the Project Overviews (Section 5) prepared by other members of the study team.

BILL BRAKEL - IN APPRECIATION

For any project to be successful, it requires a small cadre of dedicated believers. For BREAM and its predecessors BEMP and MEMP, Bill Brakel was one of those believers. He was a moving force both on stage and behind the scenes of the program since its inception in 1983.

BREAM is Bill's kind of project. He delighted in bringing the most diametrically-opposed viewpoints together and watching the human dynamics as a compromise was struck. He created many opportunities for this since the mid 70's through a diverse spectrum of issues ranging from AES to BSSC, NOGAP to MEQ, BEMP to CEPA. He was involved in more acronyms than he probably cared to remember.

Many of us have strong memories of Bill Brakel at BEMP or other workshops. Invariably the scene was not the meeting room itself, but rather the hall way or smoking room; there with a pipe in the corner of his mouth he would appraise the situation and the players and advise on what had to be done. Sometimes his summary of progress was blunt and direct; at other times he would paint some obscure and seemingly unrelated metaphor to explain our dilemma. We would then be sent back into the fray to fight for reason.

Bill delighted in making things work, in planting a seed and watching it germinate in other peoples' minds. He was happiest when the idea grew to the point that the originator, Bill himself, was forgotten. The BREAM seed was planted by Bill just before his unexpected and tragic loss and we hope that it can come to fruition without his guiding hand. Bill was a remarkable colleague and friend. He is dearly missed and will not be forgotten.

TABLE OF CONTENTS

1.	**INTRODUCTION**	1
2.	**HYDROCARBON DEVELOPMENT SCENARIO FOR BEAUFORT REGION**	6
2.1	Introduction	6
2.2	Exploration and Production	7
2.2.1	Background	7
2.2.2	Possible Development Scenarios	10
2.2.3	Production of Gas Reserves	11
2.2.3.1	Two Plant Option	11
2.2.3.2	"Industry" Plant Option	14
2.2.4	Production of Oil Reserves	16
2.3	Transportation Systems	17
2.3.1	Background	17
2.3.2	Natural Gas Pipeline System	20
2.3.2.1	Compressor Stations	21
2.3.2.2	Pipeline Route	22
3.	**THE FOCUS AND PRIORITIES OF BREAM IN THE FUTURE**	26
3.1	Introduction	26
3.2	Focus of BREAM	26
3.2.1	Major Oil Spills	27
3.2.2	Community-Based Environmental Concerns	29
3.2.3	Use of Traditional Knowledge	32
3.2.4	Assessment	33
3.3	The Value of BREAM to Industry, Government and Northern Communities	33
3.4	Definition of BREAM	35
3.4.1	Program Objectives	35
3.4.2	Spatial and Temporal Scope	36
3.4.3	Actions	37
3.4.4	Indicators	37
3.4.5	Process and Tools	37
3.5	Issues to be Addressed by BREAM	38
3.5.1	Existing BEMP Impact Hypotheses	38
3.5.2	Existing MEMP Impact Hypotheses	41
3.5.3	Additional Issues	43
3.5.3.1	Major Oil Spills	43
3.5.3.2	Community-Based Concerns	44
3.5.3.3	Other Concerns	44

TABLE OF CONTENTS (Continued)

3. THE FOCUS AND PRIORITIES OF BREAM IN THE FUTURE (Continued)

3.6 Action Plan for BREAM 46
3.6.1 Creation of Steering Group 46
3.6.2 Creation of Technical Working Groups 47
3.6.2.1 Review of Existing Impact Hypotheses 47
3.6.2.2 Catastrophic Oil Spill Background Information 48
3.6.2.3 Community-Based Environmental Concerns 49
3.6.3 Determination of Assessment Methodology 49
3.6.4 Liaison to Develop Support 50
3.6.5 Program Announcements and Updates 50
3.6.6 Workshops in 1991-1992 Fiscal Year 50

4. BEAUFORT SEA INFORMATION DATABASE REQUIREMENTS 52

4.1 Introduction 52
4.1.1 Background to Workshop 52
4.1.2 Workshop Scope 54
4.1.3 Definitions 55
4.1.4 Framework for Assessing Information Requirements 56
4.2 Summary of Information Needs 57
4.3 Marine Countermeasures Plan 57
4.4 Shoreline Cleanup Plan 59
4.5 Wildlife Protection Plan 60
4.6 Wildlife Habitat Restoration 62
4.7 Environmental Assessment 63

5. RECENT RESEARCH OF RELEVANCE TO BREAM 68

5.1 Research Relevant to BEMP Hypotheses 81
5.2 Research Relevant to MEMP Hypotheses 273
5.3 Research Relevant to New BREAM Issues 399

LIST OF ACRONYMS

AES	Atmospheric Environment Service (Environment Canada)
BEMP	Beaufort Environmental Monitoring Project
BREAM	Beaufort Region Environmental Assessment and Monitoring Program
BSSC	Beaufort Sea Steering Committee
CEARC	Canadian Environmental Assessment Research Council
CEPA	Canada Environmental Protection Act
CPA	Canadian Petroleum Association
CWS	Canadian Wildlife Service (Environment Canada)
DOE	Department of Environment
DFO	Department of Fisheries and Oceans
EARP	Environmental Assessment and Review Process
EIA	Environmental Impact Assessment
EIRB	Environmental Impact Review Board
ESRF	Environmental Studies Research Funds
FJMC	Fisheries Joint Management Committee
GNWT	Government of the Northwest Territories
HTA	Hunters and Trappers Association
IFA	Inuvialuit Final Agreement
IGC	Inuvialuit Game Council
INAC	Indian and Northern Affairs Canada
IPL	Interprovincial Pipe Line Ltd.
MEMP	Mackenzie Environmental Monitoring Project
NEB	National Energy Board
NOGAP	Northern Oil and Gas Action Plan
PERD	Panel on Energy Research and Development
ROW	Right-of-way
SCAT	Spill Cleanup and Assessment Team
VEC	Valued Ecosystem Component
VSC	Valued Social Component
WMAC	Wildlife Management Advisory Council
YTG	Yukon Territorial Government

BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROGRAM

EXECUTIVE SUMMARY

This report summarizes the first year (1990/91) of the Beaufort Region Environmental Assessment and Monitoring Program (BREAM).

Background

In 1983, Indian and Northern Affairs Canada (INAC) and the Department of Environment (DOE) initiated the Beaufort Environmental Monitoring Project (BEMP). BEMP was intended to provide the technical basis for design, operation and evaluation of a comprehensive and defensible environmental research and monitoring program to accompany hydrocarbon development in the Beaufort Sea relative to the environmental and regulatory responsibilities of these departments. A similar program (the Mackenzie Environmental Monitoring Project, MEMP) was initiated in 1985 by INAC, DOE, the Department of Fisheries and Oceans (DFO), and the Governments of the Northwest Territories (GNWT) and Yukon (YTG) to address research and monitoring requirements related to oil and gas development and transportation systems in the Mackenzie Delta and Valley. Multi-disciplinary workshops to develop or refine environmental monitoring programs for the Beaufort Sea or Mackenzie Delta and Valley have not been held since 1986. In the intervening 5-year period, several significant events have occurred.

1. The Inuvialuit Final Agreement (IFA) led to the establishment of several joint management structures as well as a need to incorporate local Inuvialuit concerns into development plans to an even greater extent.

2. The Environmental Impact Review Board (EIRB) identified environmental assessment and monitoring deficiencies during the course of its review of the Isserk (Esso) and Kulluk (Gulf) drilling proposals. The EIRB recommended not to approve Gulf Canada's Kulluk drilling program because, in part, of these apparent deficiencies.

3. Government established the Beaufort Sea Steering Committee (BSSC) to address issues related to offshore oil and gas development. The BSSC submitted a final report to the Minister of INAC on 02 May, 1991. A long-term, technically-based process is needed to focus research and monitoring in the future.

4. The catastrophic oil spill, which was not considered in BEMP or MEMP, has received high public attention because of recent incidents such as the NESTUCCA and the EXXON VALDEZ spills. New and practical information on oil spill behaviour, cleanup, biodegradation and impacts on shoreline ecosystems is now available.

5. In August 1989, the National Energy Board granted natural gas export licences to Esso, Shell and Gulf. In early 1991, a consortium of producers and pipeline companies announced its intention to work toward a common Mackenzie Valley pipeline application.

6. A number of relevant Northern Oil and Gas Action (NOGAP) projects have been completed since 1986 and new NOGAP funds were approved to extend the program to 1993/94. There is no existing mechanism to focus the NOGAP work with regard to monitoring, assessment and related research.

In light of these events and the need to combine and co-ordinate the efforts of BEMP and MEMP within a common framework, a new initiative was considered necessary.

First Year of BREAM

The first year of BREAM focused primarily on a range of planning activities to help determine the direction of the program over the next few years. This report summarizes these activities and includes the following four sections.

1. Development Scenario

   This section describes the most current hydrocarbon development and transportation scenario for the Beaufort Sea and the Mackenzie Delta and Valley regions. It also includes a review of current industry projections on the timing and location of future exploration, production and transportation aspects of development, which will provide the necessary focus for evaluating the validity of impact hypotheses formulated for BREAM.

2. Results of a Planning Meeting (Calgary, 19-20 March 1991).

   It was agreed that BREAM would build on the strengths of BEMP and MEMP. In particular, research must be relevant to a linkage between a Valued Ecosystem Component (VEC) and a development "action", and the process must be iterative with each subsequent workshop furthering the goal of identifying research in the region that provides relevant information. It was also agreed that BREAM would consider catastrophic

   oil spills and focus more on community based environmental concerns.

   The remainder of this section discusses the BREAM objectives and the actions and activities that should be undertaken during the 1991/92 fiscal year to move BREAM from the planning phase into an operational mode.

3. Summary of a Workshop (Calgary, 17-18 January 1991).

This section summarizes the results of a workshop conducted on 17-18 January 1991 in Calgary to discuss Beaufort Sea Information Database Requirements (see Appendix B for List of Participants). The workshop objective was to examine the sufficiency of existing databases to enable the EIRB to review offshore drilling proposals relative to its Inuvialuit Final Agreement mandate (i.e. wildlife harvesting and compensation as specified in Sections 11 and 13 of the IFA).

4. Project Reviews of relevant research and monitoring initiated or completed since 1986.

This section reviews the results of research initiated or completed since 1986 when the last evaluation of this type occurred. This task focused on studies that: (1) are known to be relevant to one or more of the existing BEMP and MEMP impact hypotheses; (2) are expected to provide the necessary background for definition of those hypotheses which will focus on community-based socio-economic concerns; and (3) will assist in the development and assessment of impact hypotheses related to major oil spills in the Beaufort Region.

All of the BEMP impact hypotheses and their linkages as they were presented in the 1986-1987 BEMP report (INAC and Environment Canada 1988) are listed, including a discussion of the major findings of research and its relevance to BREAM. Each of the studies is described and cross referenced to the relevant BEMP and MEMP hypotheses.

PROGRAMME DE SURVEILLANCE ET D'ÉVALUATION ENVIRONNEMENTALES DANS LA RÉGION DE BEAUFORT

SOMMAIRE

Le présent rapport donne un bref aperçu de la première année de fonctionnement du Programme de surveillance et d'évaluation environnementales dans la région de Beaufort (PSEERB).

Contexte

En 1983, le ministère des Affaires indiennes et du Nord canadien et le ministère de l'Environnement lançaient le Programme de surveillance environnementale dans la mer de Beaufort (PSEMB). Le PSEMB devait servir de base technique à la conception, au fonctionnement et à l'évaluation d'un vaste programme de recherche et de surveillance environnementales justifiable dans le cadre des projets de mise en valeur des hydrocarbures dans la mer de Beaufort conformément aux responsabilités en matière d'environnement et de réglementation de ces ministères. En 1985, le MAINC, le ministère de l'Environnement, le ministère des Pêches et des Océans ainsi que le gouvernement des Territoires du Nord-Ouest (GTNO) et le gouvernement du Yukon (GY) lançaient un programme semblable (le programme de surveillance environnementale du Mackenzie, PSEM) afin de satisfaire aux besoins en matière de recherche et de surveillance liés aux projets pétroliers et gaziers et aux systèmes de transport dans le delta et la vallée du Mackenzie. Aucun atelier multidisciplinaire visant à améliorer les programmes de surveillance environnementale n'a été offert depuis 1986. Au cours des cinq dernières années, des événements d'envergure se sont produits.

1. La Convention définitive des Inuvialuit (CDI) a donné lieu à l'établissement de plusieurs structures de gestion conjointe, créant ainsi un besoin encore plus grand d'incorporer les préoccupations des Inuvialuit aux plans de développement.

2. Le Bureau d'examen des répercussions environnementales (BERE) a découvert des anomalies en matière de surveillance et d'évaluation environnementales au cours de l'étude des projets de forage Isserk (Esso) et Kulluk (Gulf). Le BERE a recommandé de ne pas approuver le programme de forage Kulluk de la Société Gulf du Canada en raison, partiellement, de ces anomalies apparentes.

3. Le gouvernement a établi le Comité directeur de l'exploitation dans la mer de Beaufort (CDEMB) afin qu'il s'occupe des questions liées à l'exploitation pétrolière et gazière au large des côtes. Le CDEMB a présenté son rapport final au ministre du MAINC le 2 mai 1991. Il faut disposer d'un processus technique à long terme pour centraliser la recherche et la surveillance à l'avenir.

4. Le déversement désastreux de pétrole, qui n'a pas été étudié dans le cadre du PSEMB ou du PSEM, a suscité beaucoup d'intérêt auprès du public en raison notamment des incidents récents comme les déversements du NESTUCCA et de l'EXXON VALDEZ. Il est possible d'obtenir de nouvelles données pratiques sur le phénomène des déversements, la dépollution, la biodégradation et les répercussions sur les écosystèmes marins.

5. En août 1989, l'Office national de l'énergie a délivré aux sociétés Esso, Shell et Gulf des permis d'exportation de gaz naturel. Au début de 1991, un consortium de producteurs et de sociétés de pipelines a annoncé son intention de travailler à l'adoption d'applications collectives en matière de pipelines dans la vallée du Mackenzie.

6. Un certain nombre de projets pertinents ont été menés à terme dans le cadre du Programme d'initiatives pétrolières et gazières dans le Nord (PIPGN) depuis 1986 et de nouvelles mises de fonds ont été approuvées en vue de prolonger le programme jusqu'en 1993-1994. Il n'existe pas de mécanismes susceptible de centraliser les travaux du PIPGN en ce qui concerne la surveillance, l'évaluation et la recherche connexe.

Compte tenu de ces événements et de la nécessité de coordonner les activités du PSEMB et du PSEM et de les combiner en une seule structure, il s'est avéré nécessaire de prendre une nouvelle initiative.

Première année du PSEERB

Au cours de la première année du PSEERB, on s'est livré surtout à des activités de planification visant à déterminer l'orientation du programme pour les quelques années suivantes. Le présent rapport en donne le sommaire en fonction des quatre sections suivantes.

1. Scénario relatif à la mise en valeur

   Cette section décrit le scénario le plus courant en matière d'exploitation et de transport des hydrocarbures dans les régions de la mer de Beaufort et du delta et de la vallée du Mackenzie. Elle comprend aussi l'étude des prévisions actuelles de l'industrie en ce qui concerne le moment à prendre en considération et le lieu où se dérouleront les activités liées à la prospection, la production et le transport, facteurs qui permettront d'évaluer la validité des hypothèses formulées dans le cadre du PSEERB.

2. Résultats de la réunion en matière de planification (Calgary, 19 et 20 mars 1991)

   Il avait été convenu que le PSEERB complèterait le PSEMB et le PSEM. En particulier, la recherche doit permettre de faire un lien entre la composante valorisée d'un écosystème (CVE) et une "mesure" relative à la mise en valeur; le processus doit être itératif et chaque atelier subséquent doit contribuer à faire avancer la recherche dans la région qui fournit les données pertinentes. En outre, il avait été décidé que le PSEERB tiendrait compte des déversements désastreux et s'appliquerait davantage aux préoccupations communautaires en matière d'environnement.

   Cette section fait ensuite état des objectifs du PSEERB et des mesures à prendre au cours de l'exercice financier 1991-1992 pour que le programme passe de l'étape de la planification au mode opérationnel.

3. Sommaire d'un atelier (Calgary, 17 et 18 janvier 1991)

   Cette section donne un aperçu des résultats de l'atelier tenu les 17 et 18 janvier 1991 à Calgary en vue de discuter des besoins en matière de base de données sur la mer de Beaufort (voir la liste des participants dans l'annexe B). L'atelier avait pour but de déterminer si les bases de données actuelles permettaient au BERE d'examiner les projets de forage au large des côtes par rapport à la Convention définitive des Inuvialuit (récolte de la faune et indemnisation conformément aux articles 11 et 13).

4. Examen des projets de recherche et de surveillance mis en oeuvre depuis 1986

   Cette section donne un aperçu des résultats des projets de recherche mis en oeuvre depuis 1986, au moment de la dernière évaluation. Cette tâche portait surtout sur les études: (1) reconnues comme étant liées à une hypothèse ou plus formulées dans le cadre du PSEMB et du PSEM, (2) susceptibles de servir de base à la définition des hypothèses entourant les préoccupations socio-économiques des collectivités et (3) propres à contribuer à l'élaboration et à l'évaluation des hypothèses sur les répercussions des grands déversements de pétrole dans la région de Beaufort.

Cette section fait état de toutes les hypothèses formulées dans le cadre du PSEMB ainsi que les liens y afférents contenus dans le rapport de 1986-1987 (MAINC et ministère de l'Environnement 1988), y compris les principales constatations découlant de la recherche et leur importance par rapport au PSEERB. Chaque étude est décrite et examinée en fonction des hypothèses pertinentes formulées dans le cadre du PSEMB et du PSEM.

1.0 INTRODUCTION

In 1983, Indian and Northern Affairs Canada (INAC) and the Department of Environment (DOE) initiated the Beaufort Environmental Monitoring Project (BEMP) to provide the technical basis for design, operation and evaluation of a comprehensive and defensible environmental research and monitoring program to accompany hydrocarbon development in the Beaufort Sea relative to the environmental and regulatory responsibilities of these departments. A similar program (the Mackenzie Environmental Monitoring Project, MEMP) was initiated in 1985 by INAC, DOE, the Department of Fisheries and Oceans (DFO), and the Governments of the NWT (GNWT) and Yukon (YTG) to address research and monitoring requirements related to oil and gas development and transportation systems in the Mackenzie Delta and Valley. Multi-disciplinary workshops to develop or refine environmental monitoring programs for the Beaufort Sea or Mackenzie Delta and Valley have not been held since 1986. In the intervening 5-year period, several significant events have occurred.

1. The Inuvialuit Final Agreement (IFA) led to the establishment of several joint management structures including the Inuvialuit Game Council (IGC), the Wildlife Management Advisory Council (WMAC) and the Fisheries Joint Management Committee (FJMC), as well as a need to incorporate local Inuvialuit concerns into development plans to an even greater extent than has been the case for the past two decades of hydrocarbon exploration activity in the Beaufort region.

2. The Environmental Impact Review Board (EIRB) established under the IFA identified environmental assessment and monitoring deficiencies related to offshore oil and gas development during the course of its review of the Isserk (Esso) and Kulluk (Gulf) proposals. The EIRB recommended not to approve Gulf Canada's Kulluk drilling program because, in part, of these apparent deficiencies.

3. Government established the Beaufort Sea Steering Committee (BSSC) and related Task Groups to address issues related to offshore oil and gas development. These were, however, an interim and short-term mechanism. The BSSC submitted a final report to the Minister of INAC on 02 May 1991. A long-term, technically-based process is needed to focus research and monitoring in the future.

4. The catastrophic oil spill, which was not considered in BEMP or MEMP, has received high public attention because of a number of recent incidents. Oil spills in other geographic areas including the NESTUCCA spill in B.C. and the EXXON VALDEZ spill in Alaska have provided new and practical information on oil spill behaviour, cleanup, biodegradation and impacts on shoreline ecosystems. Much of the data may be relevant to questions related to chronic and catastrophic oil spills in the Beaufort Sea.

5. Mackenzie Delta natural gas production and pipeline transportation could begin as early as 1998. The August 1989 decision of the National Energy Board granting natural gas export licences to Esso, Shell and Gulf is a significant event in relation to future gas development in the region. In early 1991, a consortium of producers and pipeline companies announced its intention to work toward a common pipeline application.

6. A number of NOGAP projects providing relevant information to improve the quality of impact predictions and associated research and monitoring in the Beaufort Sea have been completed, and $10 M in new NOGAP funds were approved in January 1990. There is no existing mechanism to focus the work with regard to monitoring, assessment and related research.

This information can now be used to satisfy the continuing need for a contemporary, comprehensive and defensible environmental assessment and monitoring program to prepare for hydrocarbon development in the Western Arctic. In light of these events and the need to combine and coordinate the efforts of BEMP and MEMP within a common framework, a new initiative was considered necessary. This initiative has been termed the Beaufort Region Environmental Assessment and Monitoring (BREAM) program.

As environmental assessment, research and monitoring are integral to BREAM, they are defined below:

> **ENVIRONMENTAL ASSESSMENT** - is a process whereby the risk (probability), nature, magnitude and duration of potential effects of a development or other activity are evaluated and decisions made regarding the possible significance of a resultant changes in the biophysical and socioeconomic environments.
>
> **MONITORING** - in the context of BREAM and earlier processes (BEMP and MEMP), is the repetitive measurement of variables to detect changes directly or indirectly attributable to a specific development activity. Monitoring is the test of an impact hypothesis to: (1) measure environmental impacts; and (2) analyze cause-effect relationships.
>
> **RESEARCH** - in the context of BREAM, is the test of a system process hypothesis or baseline measurements necessary to adequately describe components of the biophysical environment and/or interpret the results of monitoring.

This first year of BREAM has focused primarily on a range of planning activities to help determine the direction of the project over the next few years. The present report summarizes the results of these activities and includes the following sections: (1) a description of the most current hydrocarbon development and transportation scenario for the Beaufort Sea region; (2) the results of a Planning Meeting (Calgary, 19-20 March 1991) designed to determine the focus and priorities of BREAM relative to earlier initiatives of this type; (3) a summary of a workshop (Calgary, 17-18 January 1991) that examined Beaufort Sea Information Database Requirements; and (4) reviews of research and monitoring initiated or completed since 1986 that was considered relevant to either existing BEMP or MEMP Impact Hypotheses or was expected to be important given the broader focus of BREAM.

A large number of individuals from government, industry and the private sector (Table 1) were involved in the planning phase of BREAM, and it is anticipated that an even greater number of agencies and representatives of northern communities will participate in the program in 1991/1992.

TABLE 1

PARTICIPANTS IN VARIOUS 1990/1991 BREAM ACTIVITIES

GOVERNMENT AND OTHER AGENCIES	INDUSTRY	PRIVATE SECTOR CONSULTANTS
Indian and Northern Affairs Canada	Esso Resources Canada	ESL - Seakem Group
Environment Canada	Gulf Canada Resources	ESSA
Department of Fisheries and Oceans	Amoco Canada Petroleum	LGL
Fisheries Joint Management Committee	Chevron Canada Resources	North-South Consultants
Government of the Northwest Territories	Polar Gas	Arctic Sciences
Government of Yukon	Foothills Pipelines	Hardy BBT
		Delta Group
		Lutra Associates
		Harper Environmental Services

2. BEAUFORT REGION HYDROCARBON DEVELOPMENT SCENARIO

2.1 INTRODUCTION

The following describes the likely nature and scope of future hydrocarbon development in the Mackenzie Valley and Delta, and nearshore and offshore regions of the Beaufort Sea. It includes a review of current industry projections on the timing and location of future exploration, production and transportation aspects of development, which will provide the necessary focus for evaluating the validity of impact hypotheses formulated for the Beaufort Region Environmental Assessment and Monitoring Program.

The information presented below is based on material provided by a number of industry representatives and has been supplemented with notes taken by ESL during various telephone conversations with these individuals. A report prepared in March 1989 for the Canadian Petroleum Association by R.A. Owens Environmental Services Ltd. ("Land Use Requirements for Anticipated Hydrocarbon Development in the Mackenzie Delta-Beaufort Sea Land Use Planning Region") provided much of the basis of the scenario for oil and gas development in the Delta and Beaufort Sea. Additional information on potential gas development in the Mackenzie Delta and construction of an associated gas pipeline was provided by Foothills Pipe Lines (Rob Owens) and Polar Gas Limited (Rick Hoos, Mackenzie Delta Pipeline Project), as well as Esso Resources Canada Ltd. (Evan Birchard).

2.2 EXPLORATION AND PRODUCTION

2.2.1 Background

To date, production of hydrocarbon reserves within the BREAM study area has only occurred at the Norman Wells field. Oil production began in 1921, when a topping plant was constructed by Imperial Oil Limited. Hydrocarbon activity continued to focus primarily on Norman Wells until the 1950s, when interest extended into the Mackenzie Delta area. In the mid 1980s, a number of new wells were drilled at Norman Wells to increase production from this field, and a small diameter oil pipeline was constructed.

In 1961, the first exploratory well was drilled in the Mackenzie Delta and since then interest has been increasingly focused on the Delta region and nearby offshore areas of the Beaufort Sea. To date, more than 200 wells have been completed and a number of significant oil and gas finds have been discovered. While only a single well has been drilled at some sites, a number of wells have been completed at others in an effort to define the volume and extent of petroleum reserves. Despite these significant discoveries, high expectations of this region have not been met. Unlike the Alaskan North Slope where a small number of large, prolific fields exist, the Mackenzie/Beaufort region is characterized by a large number of smaller, widely scattered reserves due to highly structured and fractured sedimentary strata. Production from these fields will be more difficult and expensive, requiring more extensive gathering systems than those used in Alaska.

Although the most attractive prospects in this region have likely been examined, exploration for oil and natural gas has continued, being stimulated at times by oil prices and the perceived need for gas. Exploration activity is presently occurring in three geographic areas: Norman Wells, Colville Lake, and the Mackenzie Delta/Beaufort Sea. Most of this work is being completed largely to meet existing commitments. For example, wells drilled recently by Esso at their Tuk tertiary gas/oil field (20 km south of the hamlet of Tuktoyaktuk) were to satisfy prior commitments with the Inuvialuit Petroleum Corporation. There is little activity by Petro-Canada in the Colville Lake area at present, although there have been some significant discoveries. Renewed interest in exploration could follow development/pipeline initiatives and increased activity by other companies.

Minimal exploration is expected to continue in the short term (i.e., 3-4 years). Some industry representatives expect only 0-2 wells to be drilled in any given year, although there is the potential for additional drilling commitments (albeit small) because of new land issuances for the region. In the offshore, most exploration will probably be completed either in the summer from drilling platforms and bottom-founded structures, or in winter within the landfast ice zone. It is expected that exploration activity in the Norman Wells and Colville Lake regions will continue to be supported from Norman Wells, while activity in the Mackenzie Delta/Beaufort Sea will be supported from the communities of Inuvik, Tuktoyaktuk and a number of bases located in the northern part of the Delta.

While the exploration phase is expected to continue in the near term, there is increasing interest on the part of the petroleum industry to develop both oil and gas reserves in the Beaufort region over the long term. Although world oil prices are presently a limiting factor in the production of oil from the Beaufort/Mackenzie Delta region, the primary concern is that insufficient oil reserves have been discovered to date to justify production. The producers believe that if other significant reserves like those in the Amauligak structure are found, development of these reserves would be economically feasible (E. Birchard, Esso, pers. comm.). Development of natural gas would be purely market driven. At present, production of Mackenzie Delta gas is not viewed as being economically viable due to a surplus and current low price of this commodity, and the existence of lower cost alternate supply sources. However, this situation is likely to change in the late 1990s, as both prices and market demand increase.

It is also emphasized that while conventional gas reserves are declining, the Beaufort/Mackenzie region has large proven reserves.

The sequence and schedule of development of proven reserves in the region is uncertain and will depend on several factors including the nature of the initial development plan and the transportation system put into place to support it. From the producers' perspective, there is no priority in terms of whether oil or gas development comes first, although they are cautiously pursuing the production of natural gas from the Delta. In 1989, the three principal Delta Gas reserve owners, Esso Resources Canada, Gulf Canada Resources and Shell Canada received conditional approval from the National Energy Board (NEB) for the right to export approximately 9.2 trillion ft^3 (tcf) of natural gas from the Mackenzie Delta area. This significant decision, which is currently being subjected to an environmental screening process prior to being ratified by the federal cabinet, represents an important step needed for proceeding with a request for a Certificate to construct a pipeline along the Mackenzie Valley.

The three major producers (Esso, Shell and Gulf) and the three main pipeline companies (Polar Gas, Foothills and Interprovincial) interested in a Mackenzie Valley pipeline have agreed to work together to establish a Joint Venture. A Statement of Principles was recently signed by this group. The initial purpose of a joint venture would be to obtain the necessary approvals to build a mutually-acceptable transportation system to transport Mackenzie Delta gas to southern pipeline infrastructures. It is anticipated that development of a gas pipeline would provide a major stimulus for further exploration and delineation drilling of already discovered fields. Although the Mackenzie Valley (other than the Norman Wells area) is rated as having a "low to moderate hydrocarbon potential" compared to the Delta, which has been shown to have a "high hydrocarbon potential", a pipeline development would also provide the impetus for renewed interest in exploration along the Valley, particularly in the vicinity of the pipeline right-of-way (ROW). To date, some 60-70 wells have been drilled in the valley over the past two decades (E. Birchard, Esso. pers. comm.).

2.2.2 Possible Development Scenarios

From the producers' perspective, there are currently three scenarios for hydrocarbon development in the region (E. Birchard, Esso, pers. comm.):

1. **"Small Oil Development"** - This would involve the construction of a small diameter (8-10") pipeline to transport oil from the Delta to Norman Wells, where it would tie into the existing Interprovincial Pipe Line (IPL) system. This would involve the transport of 15,000-25,000 barrels/day of oil and would see small onshore fields such as Atkinson brought into production. This scenario is not considered to be economically feasible at the present time, given the high tariffs on this type of pipeline.

2. **"Big Oil Development"** - This would involve the construction of a large diameter (20-24") pipeline that would transport oil (about 100,000 bbls/day) from proven oil reserves in the Delta and nearshore Beaufort Sea. The lead field would be Amauligak. This pipeline would tie into other lines in Alberta. A "Big Oil Development" would involve its own pipeline and would require that Amauligak come into production, as well as other significant onshore and offshore fields.

3. **"Big Gas Development"** - This would initially involve production of Delta natural gas reserves from three fields: Taglu, Parsons Lake and Niglintgak. Production from these fields would keep a large diameter (30-36") pipeline filled to capacity for 8-10 years. Because project financing would require that the line be operated at capacity for 20 to 25 years, other fields would have to be brought into production. If an oil pipeline

was already in place at this time, the liquid condensate from processing of the natural gas would be fed into the existing line. If there is no infrastructure in place, then a small-diameter liquids pipeline could be constructed.

"Small gas development" is not considered an option because it would require a large throughput to be economically feasible.

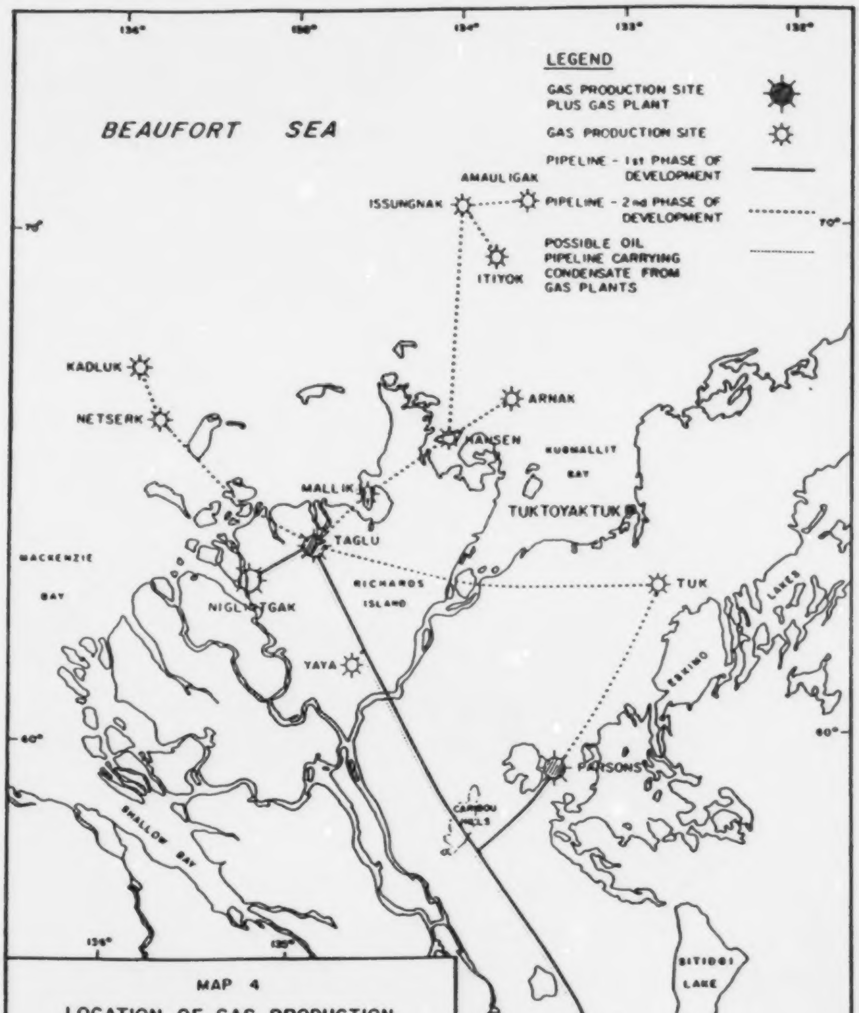
2.2.3 Production of Gas Reserves

The following description of most probable scenarios for production of natural gas reserves in the Mackenzie Delta/Beaufort region has been taken largely from discussions with industry representatives and CPA (1989).

2.2.3.1 Two Plant Option

The likely scenario for the first phase of gas development in the region would be the construction of a gas processing plant at Taglu on Richards Island and one at Parsons Lake on the mainland. Gas reserves at Niglintgak on Richards Island would be processed at Taglu. Taglu, Parsons Lake and Niglintgak are the largest gas reserves located to date in the Delta. Figure 1 shows the location of gas production, processing and transportation facilities in a development scenario involving two gas plants. Drilling operations and construction of gathering systems at the three fields, as well as construction of the two gas plants, would be sequenced over a four-year period. However, it is conceivable that the gas could initially be produced only from the two major fields on Richards Island (Taglu and Niglintgak), with gas from the mainland (Parsons Lake) coming onstream a few years later.

FIGURE 1
LOCATION OF GAS PRODUCTION PROCESSING AND TRANSPORT FACILITIES USING A TWO GAS PLANT SCENARIO (Adapted from CPA 1989)


134°
133°
132°
70°
LEGEND
GAS PRODUCTION SITE PLUS GAS PLANT
GAS PRODUCTION SITE
PIPELINE - 1st PHASE OF DEVELOPMENT
PIPELINE - 2nd PHASE OF DEVELOPMENT
POSSIBLE OIL PIPELINE CARRYING CONDENSATE FROM GAS PLANTS
BEAUFORT SEA
AMAULIGAK
ISSUNGNAK
ITIYOK
KADLUK
NETSERK
ARNAK
NANSEN
KUGMALLIT BAY
MALLIK
TUKTOYAKTUK
TAGLU
MACKENZIE BAY
RICHARDS ISLAND
TUK
NIGLINTGAK
YAYA
ESKIMO LAKES
PARSONS
CARIBOU HILLS
SHALLOW BAY
SITIDGI LAKE
INUVIK
MAP 4
LOCATION OF GAS PRODUCTION PROCESSING AND TRANSPORT FACILITIES USING A TWO GAS PLANT SCENARIO
CANADIAN PETROLEUM ASSOCIATION

Based on well and geological data, it is estimated that the Taglu field would require approximately 22 production wells and 2 water disposal wells to achieve maximum production efficiency. The production wells would be aligned in a group cluster, and directional drilling techniques using oil-based mud formulations would be employed to reach the optimal reservoir points. The gas produced from each wellhead would be transported to the Taglu plant via an insulated, above-ground pipeline. The plant would have a raw gas capacity of 890 MMSCFD (millions of standard cubic feet per day) in order to process both Taglu and Niglintgak gas reserves, and would process 13,000 barrels of condensates per day.

Gas from the Niglintgak field would be moved to Taglu by an above-ground insulated pipeline. Development of this field would involve approximately 10 production wells drilled vertically or from common drilling pads. Production from these wells would be gathered at a small onsite processing facility, which would separate free water and prepare the gas for shipment to Taglu.

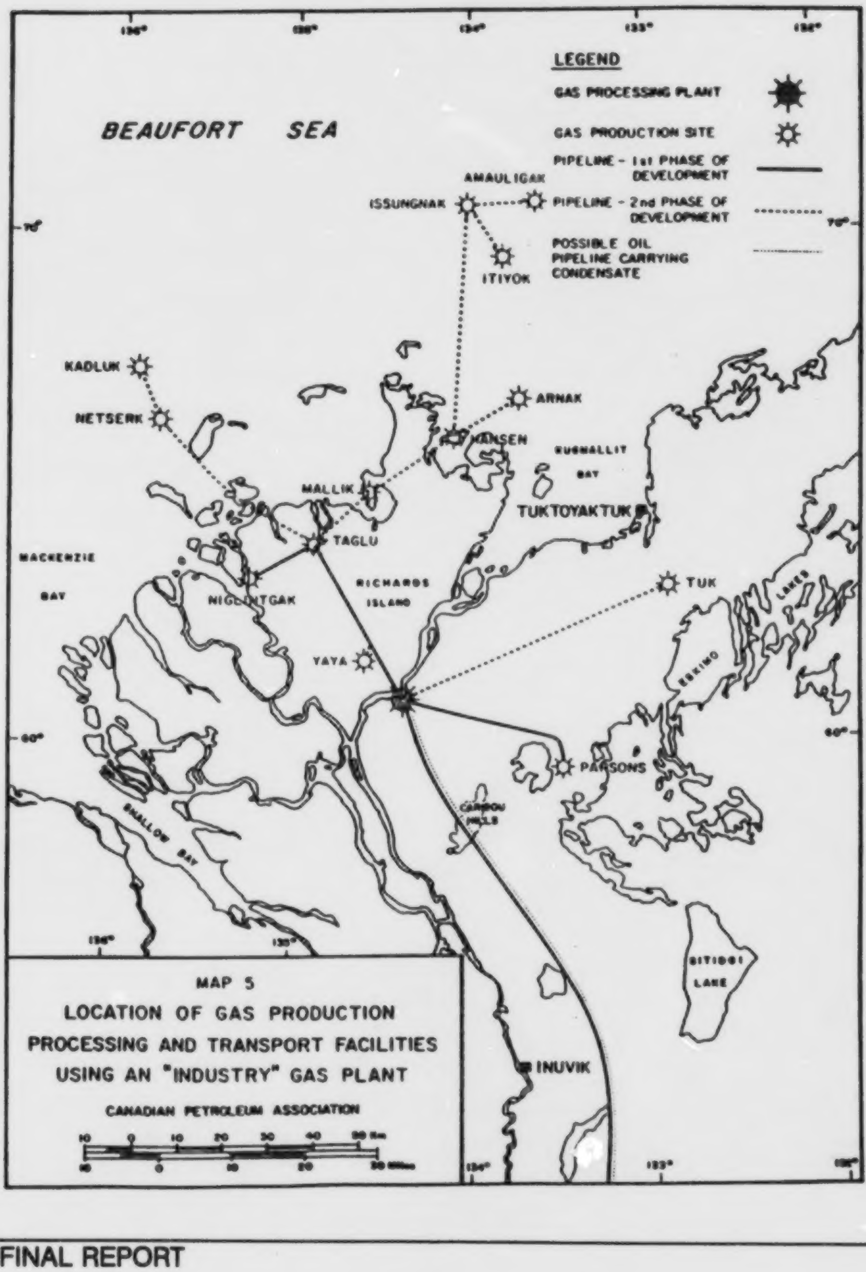
Under the two plant scenario, a separate plant would be required at Parsons Lake. This facility would be capable of processing 470 MMSCFD of gas and 6,500 barrels/day of condensates. Development of this field would involve 13 production wells drilled from two drilling pads. Above-ground gathering lines would move gas to the plant. Processed gas would be moved through below-ground pipelines to the main gas line, which would be located about 25 km to the west of the plant. Liquid hydrocarbons would be transported from both the Parsons and Taglu plants via a small liquids line, which would either parallel the natural gas pipeline route or tie in with the existing line at Norman Wells.

As these three primary gas reserves begin to deplete, a number of smaller onshore and, eventually, offshore gas fields would be developed to meet long-term gas sales requirements. These would likely include Kadluk, Netserk, Issungnak, Amauligak, Itiyok, Arnak, Hansen, Tuk and Mallik. However, more delineation drilling of these reserves would be required. Over a 25-year period, there would likely be overlapping phases of development (possibly 4-5 phases) in order to keep the pipeline operating at full capacity. Onshore reserves would likely be connected first because this would be the less expensive alternative. Gas would be transported by either refrigerated buried or above-ground insulated pipelines. Production from offshore gas fields would likely require the construction of production islands to provide a central base for the dehydration and liquid separation facilities. Gas and liquid condensates would be moved to shore via buried lines.

2.2.3.2 "Industry" Plant Option

An alternative plan for development of natural gas reserves is also under consideration. This would involve construction of a centrally-located gas plant that would serve the three major gas fields and eventually other smaller reserves in onshore and offshore areas. Currently, Swimming Point on the east channel of the Mackenzie River seems the most likely site, although other locations may be considered in the future. This scenario is illustrated in Figure 2.

FIGURE 2
LOCATION OF GAS PRODUCTION PROCESSING AND TRANSPORT FACILITIES USING A SINGLE GAS PLANT SCENARIO (Source: CPA 1989)



MAP 5
LOCATION OF GAS PRODUCTION PROCESSING AND TRANSPORT FACILITIES USING AN "INDUSTRY" GAS PLANT
CANADIAN PETROLEUM ASSOCIATION

2.2.4 Production of Oil Reserves

As stated previously, additional large proven oil reserves will likely have to be discovered before production of oil in the Mackenzie/Beaufort region is viewed as being economically feasible. While exploration of oil reserves will likely continue onshore and in the nearshore in support of future production from the region, activity in deep offshore waters of the Beaufort Sea is very unlikely in the immediate future due to high costs associated with such drilling programs.

Development of oil reserves in the region would initially involve production from the major oil discovery at Amauligak. During this first phase of development, offshore production facilities would be put in place at Amauligak and a sub-sea pipeline would be constructed to carry the oil to shore. The most likely location for the landfall would be North Point on Richards Island, which would require the construction of onshore facilities to receive, condition, store and pump the produced oil. Under this development scenario, oil would be transported south by pipeline along the Mackenzie Valley. Use of tankers to transport oil out of the north is not presently considered an option by the petroleum industry. It is likely that this line would extend from North Point and either tie in with the existing IPL line at Norman Wells or remain a separate line that follows the existing ROW. Production of new reserves at Norman Wells brought onstream in the mid 1980s is now declining, and it is estimated that the IPL pipeline will be operating only at partial capacity by the mid 1990s (E. Birchard, Esso, pers. comm.).

Once transportation systems are in place and production of Amauligak oil is onstream, nearby onshore reserves (such as Adgo, Niglintgak, Atkinson, Kumak and Kugpik) would be brought into production. These oil reserves would be connected either to the terminal at North Point or through gathering lines directed to convenient points of interconnection along the oil pipeline. Production of smaller offshore discoveries would then follow, and would be connected either through separate offshore gathering lines or existing lines (i.e., Issungak) to North Point. The locations of oil production sites and transport facilities described in this development scenario are illustrated in Figure 3.

If oil reserves in the region are developed within a similar time frame or after natural gas, gas produced at oil production sites would be moved to gas processing facilities, or to a nearby gas pipeline.

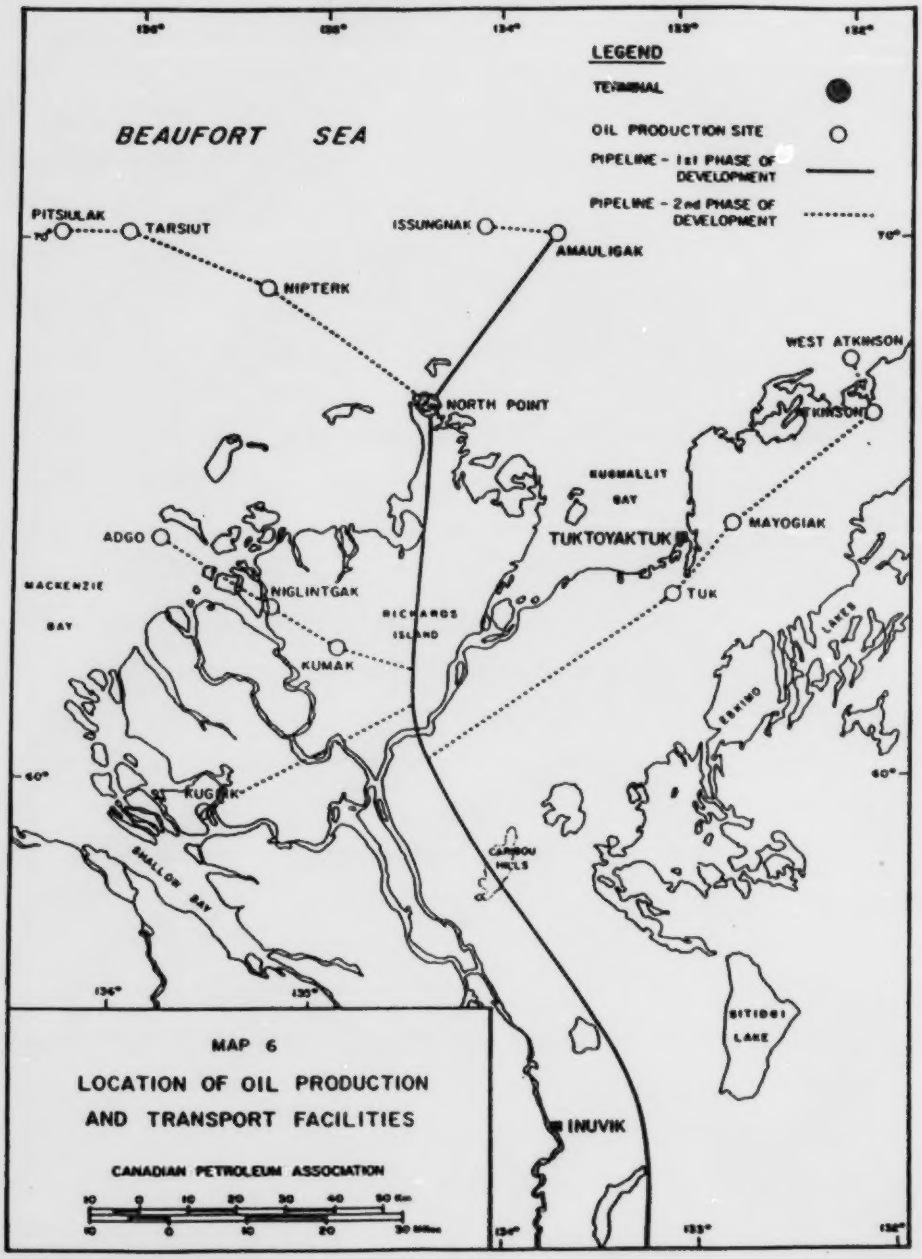
2.3 TRANSPORTATION SYSTEMS

The following material was taken largely from Polar Gas (1991) and has been supplemented to reflect discussions with other representatives of the pipeline industry.

2.3.1 Background

Based on the likely scenarios for development of oil and natural gas reserves in the Mackenzie/Beaufort region, up to three separate transmission pipelines may eventually be constructed to transport petroleum to southern markets. These include a natural gas pipeline, an oil pipeline and/or a condensate pipeline.

FIGURE 3
LOCATION OF OIL PRODUCTION AND TRANSPORT FACILITIES
(Source: CPA 1989)



The feasibility of an oil pipeline to carry both onshore and offshore oil from the Mackenzie Delta and southern Beaufort Sea south along the Mackenzie Valley has been discussed for several decades. Although such a facility is considered an essential element in the development of the region's petroleum reserves, there are currently no proposals for an oil pipeline.

As part of the plan put forward for the Alaska Highway Gas Pipeline system, Foothills Pipe Line proposed a Dempster Lateral Gas Pipeline to carry Mackenzie/Beaufort natural gas to the mainline system in the Yukon. While Foothills has a Certificate of Public Convenience and Necessity for the Alaska pipeline, there are no current initiatives to proceed with either system. Any plans for construction of the Dempster Lateral would be contingent on whether the Alaska Highway Gas Pipeline goes ahead. Transportation of Alaskan gas to southern markets via the Alaska Highway Pipeline, however, remains one of the long-term goals of Foothills. If Alaskan gas flows before Mackenzie Delta gas, then the company's interest in the Dempster line would be renewed and it would be seen as a viable development option.

At the present time, the NEB has before it two incomplete applications to build a Mackenzie Valley gas pipeline. The first was filed by Polar Gas in 1984 and was intended for the construction of a large diameter (36") pipeline from Richards Island in the Mackenzie Delta to Edson, Alberta, where it would connect with existing pipeline systems. The second application, filed by Foothills Pipelines in 1989, was for a 34" diameter pipeline extending from Richards Island to Caroline, Alberta, via Boundary Lake on the British Columbia-Alberta border. As mentioned previously, the three major producers (Esso, Shell and Gulf) and the three main pipeline companies (Polar Gas, Foothills and Interprovincial) are presently attempting to establish a new Joint Venture to transport Mackenzie Delta natural gas to southern markets. Through such a venture, it would be the intent to prepare a new pipeline application to replace the present ones. Assuming the Joint Venture effort is successful, only one joint application would proceed through the necessary public review processes, eventually leading to an NEB

Certificate of Public Convenience and Necessity.

Assuming a seven-year time frame from the start of local consultations, through hearings to certification, financing, construction and completion of a pipeline, and current projections that the necessary demand and prices needed will be reached by the end of this decade, 1998 is the earliest year that a gas pipeline along the Mackenzie Valley could become operational. Some industry representatives believe that it is more likely that construction of the pipeline would not be completed until 2000 to 2005. Although the consortium is optimistic that this project will proceed over this time frame, it is emphasized that this venture is being pursued cautiously and slowly to ensure that there is full support from the government regulatory agencies prior to proceeding with the application and that the market is secure before construction begins. Eventual timing of this development will ultimately be determined by the North American gas market demands and associated price. If the natural gas demand does not grow as expected or the price of natural gas does not increase, it is likely that the pipeline will not be built within this time frame.

2.3.2 Natural Gas Pipeline System

The following provides a brief description of how a joint Mackenzie Valley gas pipeline project might proceed. The description is of a general nature, with ranges being provided where differences between companies and their philosophies exist. It should also be emphasized that the proponents of this project expect and will promote input from all interested parties, particularly from the people and communities along the proposed route. The objective will be to ensure that the final routing and nature of the project will be both environmentally and socially acceptable in addition to satisfying the mandatory technical and economic criteria.

A natural gas pipeline along the Mackenzie Valley will be a buried pipeline approximately 1,450 miles (2,330 km) long, extending from Taglu, on Richards Island to connect to existing systems in Alberta. The pipeline will have an outside diameter of 34" -36" (864 - 914 mm) and will be designed to initially transport 1.2 billion ft^3/day (34 million m^3/day).

The natural gas will be transported at a maximum operating pressure in the range of 1,140 to 2,160 psig, with a related nominal pipe wall thickness of 0.46 to 0.51 inch (11.68 - 12.95 mm). Heavier-walled pipe will be used in regions where there is potential for pipe movement (i.e., discontinuous permafrost areas, unstable slopes, river crossings). The gas will be chilled to 32°F (0°C) or lower from Taglu through to the southerly limit of widespread permafrost between Fort Good Hope and Norman Wells, NWT. Beyond this point, the temperature of the gas will be maintained between 32° to 50°F (0°C to 10°C) to minimize thermal effects on terrain.

The pipeline system will be powered initially by 3-10 compressor stations, equipped with refrigeration and/or heating facilities to maintain a thermal balance between the pipeline and adjacent permafrost or seasonally-frozen soils. Future expansion of the system to increase gas throughput can be accommodated by adding additional compression facilities as required.

2.3.2.1 Compressor Stations

Assuming a low-pressure pipeline, 10 compressor stations would be required to initially power the pipeline system. Each of the stations will require up to 12 acres (5 hectares) for site development. The compressor stations will be designed to meet the requirements of the northern environment. To protect any underlying permafrost, the northern stations will be constructed on gravel pads and critical foundations within each station will be insulated. In addition, all of the station equipment will be enclosed in fully-insulated buildings. All emissions from the compressor stations will meet or exceed existing regulatory standards.

2.3.2.2 Pipeline Route

The past pipeline proposals have indicated a route that extends southerly from the Mackenzie Delta gas production facilities passing approximately 15 miles (24 km) east of Inuvik and continuing southeasterly past Travaillant Lake. Beyond this point, the route generally parallels the Mackenzie River to the vicinity of Fort Good Hope and then proceeds southerly to enter the Franklin Mountains west of Chick Lake. After crossing the mountains at Gibson Gap, the route continues generally parallel to the Mackenzie River and the Interprovincial Pipe Line (NW) Ltd. oil pipeline to a point approximately 40 miles (64 km) west of Fort Simpson. At this location, two primary routing options of identical length have been considered.

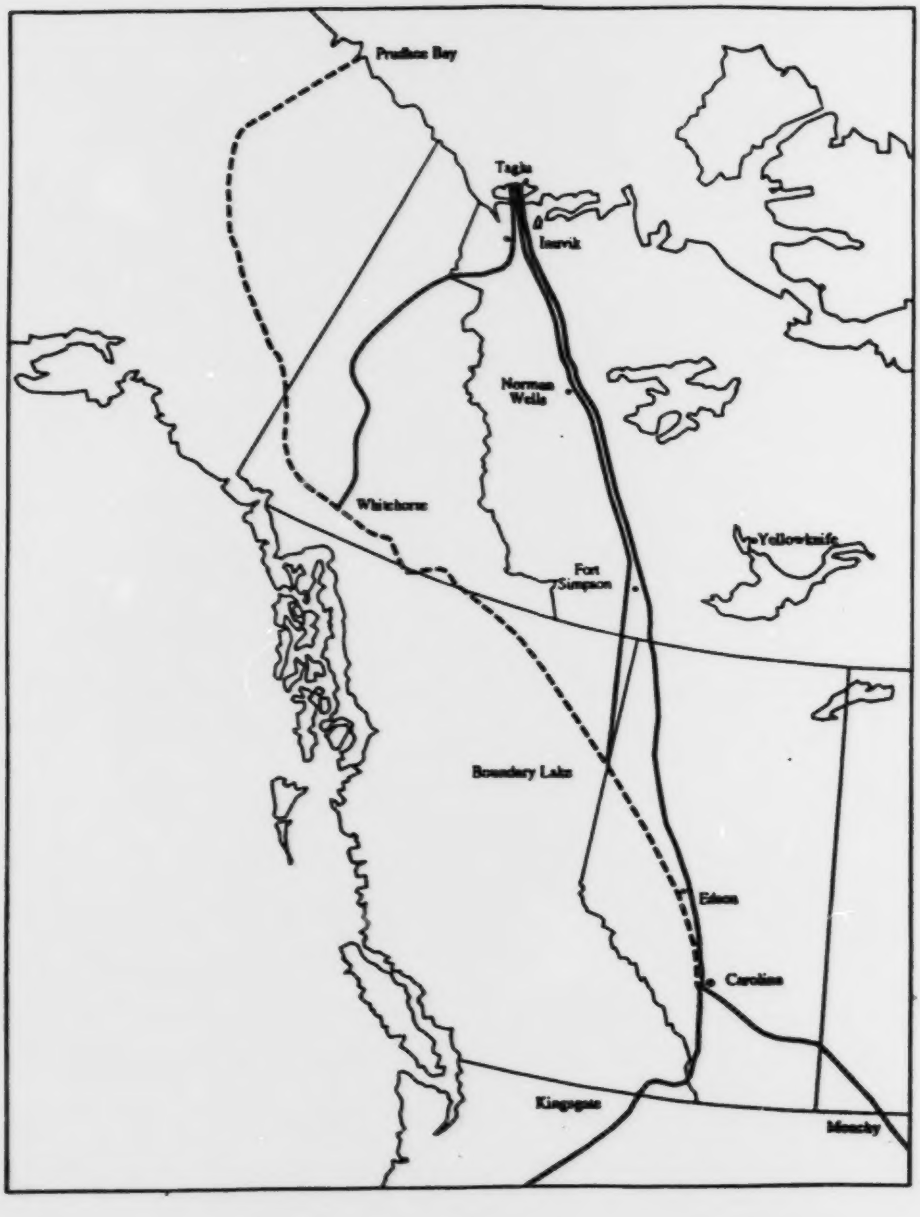
1. The "Polar Gas option" continues to follow the IPL oil pipeline right-of-way, passing to the east of Fort Simpson, where it crosses the Mackenzie River. The route then proceeds southward past Zama enroute to Caroline.

2. The "Foothills option" crosses the Mackenzie River 40 miles (64 km) west of Fort Simpson. It then crosses the Liard River heading in a southerly direction to interconnect with the facilities of Foothills Alta. on the British Columbia border near Boundary Lake. From there, the route heads southeasterly into Alberta.

Final route selection for a joint pipeline proposal will be the subject of further discussion. Decisions regarding route selection will be made by the proponents in consultation with government regulatory agencies and the communities along the proposed routes. Figure 4 shows the proposed routing alternatives to transport Mackenzie Delta gas to Alberta.

It is possible that small feeder/distribution lines would eventually be constructed off the main pipeline to transport natural gas to northern communities. It is expected that the GNWT would undertake economic analyses to determine those communities located adjacent to the pipeline route where such distribution systems may be viable over the long term.

FIGURE 4
ROUTING ALTERNATIVES TO TRANSPORT
MACKENZIE DELTA GAS



LITERATURE CITED

Canadian Petroleum Association. 1989. Land use requirements for anticipated hydrocarbon development in the Mackenzie Delta - Beaufort Sea Land Use Planning Region. Report prepared by R.A. Owens Environmental Services Ltd. for the Canadian Petroleum Association. 73 p. + appendices.

Polar Gas. 1991. Project Overview - Mackenzie Valley Pipeline. Polar Gas, Mackenzie Delta Pipeline Project, Calgary, Alberta.

3. THE FOCUS AND PRIORITIES OF BREAM IN THE FUTURE

3.1 INTRODUCTION

The BREAM Planning Meeting was held on 19-20 March 1991 in Calgary and was attended by representatives of Indian and Northern Affairs Canada (INAC), the Department of Fisheries and Oceans (DFO), Environment Canada, the Fisheries Joint Management Committee (FJMC), companies of the petroleum and pipeline industries interested in establishing a Joint Venture (Section 2.2.1), and several consultants from the project team (Appendix A). The Meeting Facilitator was Dave Bernard of ESSA Ltd., and the Rapporteur was Wayne Duval of ESL Environmental Sciences Limited.

A background document was distributed to all participants prior to the meeting. This outlined the general objectives of BREAM and the views of its authors (Wayne Duval and David Thomas) on how the project would differ from its predecessors (BEMP and MEMP). Additional material provided at the outset of the meeting included a draft version of the Hydrocarbon Development Scenario presented in Section 2, lists of existing BEMP and MEMP Impact Hypotheses, and a document that identified the titles of some recent research programmes that were considered relevant to BEMP, MEMP or BREAM.

3.2 FOCUS OF BREAM

BREAM is a NOGAP-funded initiative and is considered by its sponsoring government agencies as a process to focus the limited funds available on the most important research and monitoring priorities related to future hydrocarbon development in the region. The need for information relevant to assessing the impacts of hydrocarbon development existed throughout the 1970s and 1980s. However, in many cases, acquisition of this information was not structured in a way that it could be focused on significant scientific issues. Like its predecessors, BREAM is a process that identifies studies required to fill key data gaps and allows subsequent assessments to be more pragmatic and successful.

BREAM will build on several of the strengths of BEMP and MEMP. One of these is that research had to be relevant to a linkage between a Valued Ecosystem Component (VEC) and a development "action". As a result, BEMP/MEMP promoted studies that were relevant to environmental assessment rather than personal priorities and "pet projects" of research scientists. Some research programmes became more focused as a result of BEMP/MEMP, while others were eliminated because they could not be defended in terms of their relevance to environmental assessment. Perhaps one of the greatest merits of BEMP/MEMP was that they were iterative processes, with each subsequent workshop furthering the goal of ensuring that research in the region provided relevant information.

BREAM will also avoid some perceived and known shortcomings of BEMP and MEMP. One area in particular identified in the Planning Meeting was the failure to consider catastrophic oil spills. Both projects focused on routine aspects of hydrocarbon exploration and transportation and, therefore, explicitly excluded evaluation of research and monitoring related to environmental emergencies such as a major well blowout or oil pipeline rupture.

3.2.1 Major Oil Spills

The low risk of major spills and the associated difficulty in assigning research and monitoring priorities to low-risk events were two reasons why major spills were not addressed in BEMP and MEMP. The EXXON VALDEZ spill in Alaska, however, has changed this view. Questions related to the fate, effects and cleanup of a worst-case blowout in the region dominated the most recent EIRB review of Gulf's proposed 1990-1992 drilling programs from the Kulluk, and the Beaufort Sea Steering Committee and its associated Task Groups further examined various issues surrounding catastrophic oil spills. BREAM is, therefore, compelled to deal with major spills, not only in terms of setting research and monitoring priorities, but also from an environmental assessment perspective. It was further suggested that at least two spill scenarios should be evaluated as part of BREAM: (1) a major blowout from an offshore drilling platform; and (2) an oil pipeline rupture that affects the Mackenzie River. Notwithstanding the importance of addressing major spills, meeting participants stressed that major spills should not overwhelm the new process because they are still a low probability event relative to other impact sources, which are far more likely to exist if hydrocarbon development proceeds.

It was decided that in addressing major spills, BREAM will examine three specific areas: (1) environmental predictions; (2) mitigation; and (3) recovery, perhaps initially through the preparation of "state-of-science" literature reviews in the context of the northern environment. As a neutral process, it will strive to present an objective view of the short- and long-term impacts of oil spills because of the many misconceptions surrounding these events. These reviews will also assist in dealing with another important issue, community-based concerns, which is discussed further in Section 3.2.2.

It was suggested that oil spill modelling should be included BREAM, in part because past models have often generated more questions than answers and have been a focal point of discussions (and misunderstanding) at recent hearings. The new Beaufort Sea Oilspill Co-op model is presently undergoing further development and refinement, and is capable of addressing many concerns related to the zone of influence of offshore spills and the trajectory of oil slicks, including the effects of altering key input parameters (i.e., oil type and environmental conditions) on resultant predictions. There were three specific recommendations related to modelling: (1) preparation of a concise, non-technical document ('primer') that describes simulation models and their sensitivity to altered input parameters; (2) monitoring of the progress of the oil industry in further refinement of the Beaufort Sea Oil Spill Co-op model;

and (3) presentation and explanation of this model (even in its present state of development) in some BREAM forum such as a workshop as soon as practical.

3.2.2 Community-Based Environmental Concerns

BEMP and MEMP were structured around impact hypotheses and followed a scientific process not particularly well-suited to addressing many community-based concerns. Examples of the latter include events that occur in day-to-day life such as land use inspections. Some of these concerns would be difficult, if not impossible, to monitor within a scientific framework. In addition, many of the associated linkages may not readily be incorporated within the impact hypothesis structure. There is also an apparent problem related to communication of scientific knowledge to the native community. For example, the concern related to effects of a winter drilling program on spring ice breakup were never really addressed until the Esso Isserk EIRB review, despite the fact that a BEMP hypothesis was structured around this issue and evaluated several years earlier. Other community-based concerns could surface during subsequent public reviews, increasing the importance of identifying and evaluating these issues as part of BREAM.

In discussion of this topic, some participants suggested that community-based concerns would have to be focused through the IFA and other existing native structures because it may be difficult and ineffectual to attempt to obtain such information directly from residents of northern communities. In addition, it may be necessary to expand the VEC concept to include Valued Social Components (VSCs), although it was also suggested that BREAM may not be the vehicle to address all community-based concerns. Land Use Planning groups have identified a wide range of concerns of northern communities related to hydrocarbon development and may be able to play a role in a parallel process to BREAM.

A large number of advantages to incorporating community-based concerns into BREAM were identified:

- it would provide focus and credibility to the program from the community perspective in terms of addressing important issues to northerners;
- it would allow participation of communities in the program and any subsequent recommended research programmes;
- it would help make use of traditional knowledge;
- it would expedite approvals and project reviews;
- it would greatly help increase mutual understanding of concerns; and
- it could help northerners develop trust, reduce confrontation and aid in the demystification of science.

There are, however, also several disadvantages to addressing community-based concerns as part of BREAM:

- it could slow down the process of BREAM;
- it would increase the cost of the program;
- it could enhance expectations of northerners;
- it could increase competition for available funds including those designated for research;
- it could lead to increased emphasis on the down-side of hydrocarbon development at the community level;
- it could lead to increased confrontation if the program is not completed or is abandoned;
- it would significantly widen the scope of the program in time, space and resources;

- it could lead to confusion related to some decisions that cannot be made by BREAM or by governments, but can only be made by industry such as those relating to employment opportunities;
- it could mean that BREAM would be expected to deal with issues that it is not prepared to deal with such as land claims;
- it could be constrained by the lack of tools necessary to properly address community-based concerns within BREAM; and
- it could lead to conflicts if the northern communities want the program to be completely open-ended in the scope of issues it addresses.

Because of the importance of the decision related to incorporating community-based concerns within the BREAM program, meeting participants spent considerable time discussing which of the above disadvantages may have solutions. Sub-questions asked of participants included: (1) how large is the concern? (2) has it been solved or is it being addressed elsewhere? and (3) can it be solved as part of BREAM? Several important points were made during this discussion.

- It may be beneficial to have a broader perspective through evaluation of community-based environmental concerns. By bringing regulators into the process, they would be exposed to these broader issues.
- Community-based concerns will have to be addressed through some other process if not included within the scope of BREAM.
- It will be important to try to ensure that the same BREAM project team representatives remain involved in community liaison activities to maintain momentum and trust.
- The fact that there is no long-term funding commitment for BREAM should be explicitly stated during any discussions with representatives of native organizations and northern communities.
- If the program is able to demonstrate some initial success in dealing with community-based environmental concerns, it may be possible to secure additional funding sources beyond NOGAP.

- It will be important to maintain a proper balance between northern and southern participants during BREAM workshops.
- Although BREAM is not presently constrained in terms of the scope of issues it can address, there will be some issues (e.g., social concerns) that must be dealt with through another process.
- Some community-based issues will be focused on concerns of specific individuals such as the harvest of one hunter or trapper (where a population affect could be unmeasurable), while others will be larger issues such as global warming.

It was concluded that BREAM should address community-based environmental but not social concerns. The latter were viewed as important but more appropriately addressed through some other process.

3.2.3 Use of Traditional Knowledge

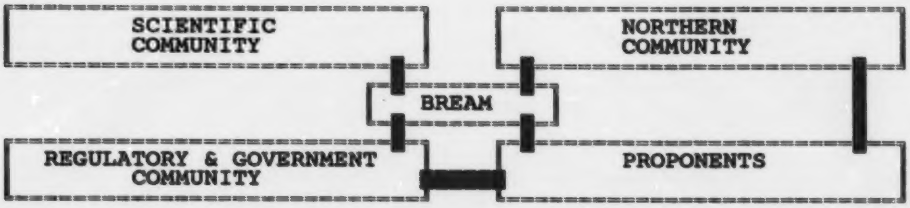
While BEMP and MEMP both attempted to use traditional knowledge by having representatives of HTAs participate in the evaluation of some impact hypotheses, it was agreed that an even greater effort should be placed on obtaining and using local knowledge during BREAM. A recent CEARC report on public participation in resource development (Bush 1990) describes a useful approach for obtaining such input, and it should be reviewed prior to initiating the next phase of BREAM. It was also suggested that there may be instances where traditional knowledge is not consistent with scientific evidence, and it may be necessary for scientists involved in the project to accept some local views even though they are not in complete agreement with the information presented.

3.2.4 Assessment

During the planning meeting, there was only limited discussion of environmental assessment as a focus of BREAM. However, it was discussed in the background paper and there appeared to be consensus that the project should place greater emphasis on environmental assessment (particularly in relation to major oil spills). One major value of increasing the focus to include assessment will be that an objective, third-party evaluation of the impacts of future hydrocarbon development and transportation proposals can be obtained prior to any further public reviews. BREAM participants can play an important role in defining the significant issues associated with development and evaluating the adequacy of information for assessment purposes. This should increase the efficiency of project approvals. The methodology for completing the assessment component of BREAM was not discussed but should be compatible with the impact hypothesis concept and also lead to conclusions on whether a potential impact is likely to be significant or insignificant.

3.3 THE VALUE OF BREAM TO INDUSTRY, GOVERNMENT AND NORTHERN COMMUNITIES

The role and importance of BREAM was examined through reference to the following diagram, which indicates interrelationships among all parties involved directly or indirectly with hydrocarbon development.



The following key points were made during this discussion:

- BREAM will help keep government funded research and industry development activities synchronized.
- Proponents and government will generate requests for information, and BREAM will provide the framework and coordination for satisfying at least some of these requests. It could act as a "clearing house for information", being able to "look in more than one direction at the same time" and matching information to needs.
- BREAM would provide the guidance, rationale, and priorities for required research including projects funded potentially through NOGAP, ESRF, PERD and departmental A-Bases. The actual research would be conducted by government scientists, universities, consultants, and organizations such as YMAC and FJMC.
- A mechanism will be required to facilitate the flow of information to and from northern communities; annual reports, newsletters and community briefings may all be used to a certain extent to achieve adequate communication. There are some vehicles other than BREAM such as the Science Institute of the Northwest Territories and the various co-management structures that can assume much of the responsibility for the linkages to northern communities.
- In terms of input to industry, BREAM will help provide consensus on the important issues related to development. It will also provide the basis for preparation of project-specific EIAs that accompany applications. The results of the EIAs will already have some acceptance as they are based on a peer-reviewed assessment and consensus on issues which are not important, impacts that can be mitigated, and issues that are not fully resolved and should be the focus of additional research.
- The Regulatory and Government community will benefit substantially from the outputs of BREAM. It will: (1) bring traditional information into a form that can influence the regulatory process; (2) assist in decision-making; (3) provide an accepted predictive environmental assessment methodology; and (4) identify the research which should be conducted and key information needs to allow government to make decisions. The benefits accrued to industry in terms of identification of significant and insignificant issues will also be of value to government and other regulators during project reviews.

3.4 DEFINITION OF BREAM

The fundamental role of BREAM is to identify information needed for decision-making. These decision-making needs will not be static but will change with time as some issues are resolved through research and assessment activities and new issues arise due to changes in the development scenario, results of recommended research and monitoring activities, site-specific land use conflicts, etc. As BREAM is an iterative process, it will be capable of responding to the dynamic nature of information needs. It was within this overall context that meeting participants defined the objectives and scope of the program.

3.4.1 Program Objectives

Four overall program objectives were defined for BREAM. These objectives are considered interim and may be refined as necessary later in the program in keeping with the iterative nature of this process.

1. To review and evaluate environmental impact assessment needs for decision-making, the state of knowledge related to scientific and community-based concerns, and related to the hydrocarbon development and transportation scenario for the region.
2. To establish the necessary lines of communication, consultation and participation between government, industry and local communities.
3. To provide the focus for what needs to be known for assessment purposes and to make decisions through establishment of a prioritized list of necessary research, monitoring and assessment activities.
4. To develop and implement the iterative process and framework to achieve the above objectives.

3.4.2 Spatial and Temporal Scope

The spatial boundaries of the program should encompass the regions within the scope of both BEMP and MEMP, but also be extended to include the proposed pipeline corridor south of Norman Wells to the Alberta-NWT border. At the same time, the spatial boundaries could include the Alaskan offshore as impacts of development in these waters (i.e., due to oil spills) may have to be addressed during the approvals process. The decision to include Alaskan waters within the scope of BREAM will be made by the program sponsors during 1991/1992. It was recognized and considered unavoidable that the spatial limits of BREAM would include areas of the Mackenzie Valley where land claim settlements have not been resolved.

The temporal bounding of BREAM must occur in relation to the development scenario, but must also reflect the decision-making process. The assessment portion of BREAM must encompass the entire period from planning, through construction and operation to decommissioning of production and transportation facilities. As indicated earlier (Section 2.3.1), the industry is not presently committed to a firm schedule related to the pace of development, although some participants suggested that project approvals may be required in the next 3-5 years. In discussion of this aspect of the project, it was emphasized that industry is only conducting work that has a "good shelf life" (e.g., collection of physical and biophysical data rather than social data); research of this nature should also be promoted by BREAM to maximize its usefulness over the long term.

3.4.3 Actions

The actions to be evaluated through BREAM are to include oil and gas industry activities *per se*, as well as associated or related activities that may be discussed during any future public reviews. It was considered practical to break these actions into categories associated with three major modules: exploration, production and transportation.

3.4.4 Indicators

In BEMP and MEMP, the "indicators" (something that can be measured that is important and will reflect a change due to an action) were termed Valued Ecosystem Components (VECs). VECs were defined as "*activities, resources, or environmental features that: (1) are important to local human populations; or (2) have national or international profiles; and (3) if altered from their existing status, will be important in evaluating the impacts of development and in focusing regulatory policy*". Because it was concluded that community-based social concerns should be addressed through some other process, this form of indicator may also be suitable for BREAM even though it must address a broad range of scientific and community-based environmental concerns.

3.4.5 Process and Tools

It was agreed that in any given year, BREAM would have four phases:

1. Planning Phase;
2. Review and Evaluation Phase;
3. Working Sessions; and
4. Reporting Phase.

This overall framework is the same as that followed during BEMP and MEMP and is expected to also be suitable for BREAM. The tools that would be employed in the program would be expanded from those used in BEMP and MEMP and could include: (1) development of structured impact hypotheses; (2) technical meetings of discipline specialists and workshops; (3) literature reviews and other project outputs; and (4) perhaps teleconferences.

The tools that would be employed in the second phase of BREAM (1991/1992) are discussed in further detail in Section 3.6 (Action Plan for BREAM).

3.5 ISSUES TO BE ADDRESSED BY BREAM

During the March 1991 Planning Meeting, each of the existing BEMP and MEMP hypotheses were reviewed in light of: (1) the current hydrocarbon development scenario; (2) concern at a local vs. regional level; and (3) new information available since the last reviews of relevant research to determine whether they should be re-evaluated and included within the scope of BREAM. This was followed by a discussion of additional issues that should be addressed during the project.

3.5.1 Existing BEMP Impact Hypotheses

Table 2 presents a list of the 21 existing BEMP impact hypotheses and the conclusions of the group on whether they should be re-evaluated by BREAM and what, if any, changes to the wording of the hypothesis were considered appropriate. In addition, the overall conclusions of previous BEMP workshop participants on the validity of each hypothesis are presented.

TABLE 2
BEMP HYPOTHESES REQUIRING RE-EVALUATION DURING BREAM

NO.	HYPOTHESIS STATEMENT	BREAM	VALIDITY/COMMENTS
1	Ship traffic, seismic programs and active offshore platforms/artificial islands will cause a reduction in the western Arctic population of bowhead whales	Yes	Valid but unlikely to be testable; no change in wording necessary
2	(a) offshore structures will reduce the white whale harvest; (b) frequent icebreaker traffic in the landfast ice will increase harvest; and (c) open water ship traffic in the Mackenzie estuary will alter white whale distribution and lead to changes in harvest levels	Yes	Sub-hypotheses (a) and (b) were considered unlikely, while (c) was concluded to be both valid and testable; no change in wording necessary
3	Marine vessel activities, seismic activities, dredging operations, aircraft overflights and active offshore platforms/islands will reduce the size of ringed and bearded seal populations in the Beaufort Sea	Yes	Valid but either too hard to detect or not worth testing; no change in wording necessary
4	Increased frequency of icebreaker traffic through (a) the landfast ice and (b) through Amundsen Gulf will reduce ringed seal pup production and population levels	Yes	(a) unlikely and not worth testing (b) valid and testable; wording should be changed to remove part (b) because no tanker traffic
5	Icebreaker traffic in the transition (shear) zone will reduce bearded seal pup production	Yes	Valid but too hard to detect; no change in wording necessary
6	Icebreaker traffic in Amundsen Gulf will affect the ringed seal and polar bear populations	No	Hypothesis unlike; no tanker traffic in development scenario
7	The presence of active facilities will result in increased polar bear mortality	Yes	Valid; no changes in wording necessary
8	Offshore hydrocarbon development activities will reduce the harvest of polar bears	Yes	Unlikely; no changes in wording necessary
9	Chronic (episodic) oil spills resulting from normal petroleum hydrocarbon development activities within and adjacent to the marine environment will result in localized mortality of polar bears	Yes	Valid; no changes in wording necessary
10	Chronic (episodic) oil spills resulting from normal petroleum hydrocarbon development activities within and adjacent to the marine environment will result in local mortality of certain species of birds	Yes	Valid; no changes in wording necessary
11	Oil slicks in open water areas around offshore structures during periods of ice cover will cause increased mortality of eiders and diving ducks	No	Valid but combined with Hypothesis No. 10

TABLE 2 (Continued)
BEMP HYPOTHESES REQUIRING RE-EVALUATION DURING BREAM

NO.	HYPOTHESIS STATEMENT	BREAM	VALIDITY/COMMENTS
12	Frequent low level flights over staging brant will cause increased overwinter mortality	Yes	Considered invalid but should be re-evaluated given 4 years of additional data
13	Shorebases and shallow-water production facilities will release (a) hydrocarbons and (b) heavy metals at sufficient levels such that fish harvest will be reduced through tainting and heavy metal accumulations	Yes	(a) Valid and testable (b) Unlikely; no change in wording necessary
14	Nearshore structures will disrupt the nearshore band of warm brackish water and reduce the broad whitefish population	No	Valid and testable, but no causeways in development scenario
15	Nearshore structures will disrupt the nearshore band of warm brackish water and will reduce the Alaskan population of Arctic cisco	No	Valid and testable, but no causeways in development scenario
16	The construction of shorebases and development of shallow-water production fields will result in a decrease in the populations of Arctic cisco and broad whitefish	Yes	Unlikely and not worth testing; revise to focus on nearshore band of brackish water and landfall of offshore pipelines
17	Water intakes will reduce populations of broad whitefish and Arctic cisco	Yes	Unlikely and not worth testing; no change in wording necessary
18	Air emissions associated with aircraft and marine traffic; and operation of drill rigs, offshore platforms and shore bases will adversely affect air quality	No	Unlikely
19	Dredging and deposition of spoils will reduce the bearded seal population	No	Valid and testable but not worth further consideration in BREAM
20	The discharge of drill cuttings contaminated with oil-based drilling muds during hydrocarbon exploration or production will reduce populations of fish, birds or mammals or will decrease the harvest of these resources due to hydrocarbon accumulation in tissues	Yes	Valid and testable; no changes in wording necessary
21	Tanker traffic and minor oil spills associated with the westward transport of Canadian Beaufort oil will cause reductions in the western Arctic population of bowhead whales and/or the harvest of this population by the Alaskan Inupiat	No	Valid but no westward tanker traffic in current development scenario

3.5.2 Existing MEMP Impact Hypotheses

A total of 25 impact hypotheses were developed for MEMP and, as indicated in Table 3, the majority of these should be re-evaluated during BREAM.

TABLE 3
MEMP HYPOTHESES REQUIRING RE-EVALUATION DURING BREAM

NO.	HYPOTHESIS STATEMENT	BREAM	VALIDITY/COMMENTS
1	The presence of offshore drilling platforms, construction camps (and associated garbage) and gravel extraction will result in a decrease in the number of Arctic and red foxes	Yes	Previous conclusion on validity should be reviewed; should consider breaking into two hypotheses because camps and garbage increase populations
2	Increased traffic on the Dempster Highway and roads on the North Slope will decrease the number of caribou and alter their distribution	Yes	Likely valid; remove reference to North Slope as no longer part of development scenario
3	Gravel extraction, construction, seismic exploration and other development activities, and the presence of camps and garbage will decrease the number of grizzly bears and alter their distribution	Yes	Valid; no changes in wording necessary
4	Oil and gas development activities will alter the water regime and decrease muskrat populations	Yes	Review rationale for previous invalid conclusion; remove reference to permanent elevated roads; change VECs to semi-aquatic mammals, birds and fish
5	Oil and gas development construction and clearing activities and the presence of an above-ground pipeline will change the abundance and distribution of moose	Yes	Unlikely; remove reference to above-ground pipelines (not in scenario) and develop new hypothesis for above-ground gathering systems
6	Oil and gas exploration and development activities that alter habitat permanently or temporarily will influence the distribution and abundance of marten	Yes	Unlikely but community-based concern; no change in wording necessary
7	Disturbance associated with hydrocarbon development in or near waterfowl staging, moulting or nesting areas will affect the abundance and distribution of waterfowl	Yes	Possible but difficult to detect; no changes in wording necessary

TABLE 3 (Continued)
MEMP HYPOTHESES REQUIRING RE-EVALUATION DURING BREAM

NO.	HYPOTHESIS STATEMENT	BREAM	VALIDITY/COMMENTS
8	Disturbance and habitat alterations due to hydrocarbon development will alter the distribution and/or abundance of raptors	Yes	Valid but low significance; no changes in wording necessary
9	The presence of camps and garbage disposal sites will attract predators that will lead to changes in the local abundance and distribution of waterfowl	Yes	Valid but low significance; no changes in wording necessary
10	Chronic (episodic) spills of crude oil and diesel fuel near staging and moulting areas or nesting colonies will reduce the abundance of waterfowl	Yes	Valid but low significance; no changes in wording necessary
11	Land subsidence resulting from hydrocarbon withdrawal will change the abundance and distribution of waterfowl, fish and muskrat	Yes	Unlikely; no changes in wording necessary
12	Air emissions resulting from oil and gas development and operation will adversely affect air quality	Yes	Invalid; should be re-evaluated but focused on specific emissions such as ice fog
13	Increased local disturbance due to activities related to hydrocarbon development will result in decreases in fish quality	No	Invalid; refers to physical disturbances
14	Improved access and fishing pressure will decrease the abundance of fish and affect their distribution	Yes	Valid; no changes in wording necessary
15	Waste discharges and accidental oil/chemical spills will lead to unpotable water and decreased acceptability of fish as a food source	Yes	Unlikely but local concern; no changes in wording necessary
16	The construction and presence of linear corridors will affect the number, distribution and quality of fish, and fishing success	Yes	Valid and community-based concern; no changes in wording necessary
17	Wolverines that are attracted to camps and garbage will be killed as nuisance animals, thus reducing the population	No	Unlikely
18	Wage employment will change the harvest of white whales	Yes	Valid for harvest composition but not level; no changes in wording necessary
19	Vessel traffic will decrease the harvest of white whales	Yes	Possible but unlikely; to be combined with BEMP No. 2

TABLE 3 (Continued)
MEMP HYPOTHESES REQUIRING RE-EVALUATION DURING BREAM

NO.	HYPOTHESIS STATEMENT	BREAM	VALIDITY/COMMENTS
20	Competition by non-locals will change the number of white whales landed and increase mortality in the population	No	Unlikely; no longer a concern due to existence of IFA structures and have to be a "beneficiary" to harvest belugas
21	Increased or improved access associated with hydrocarbon development will increase the harvest of waterfowl, which will lead to a reduction in the number and alter the distribution of waterfowl	Yes	Valid but unlikely; no changes in wording necessary
22	Increased levels of wage employment will change the total annual harvest of resources by communities in the region	Yes	Invalid in 1986; no changes in wording necessary
23	Changes in access will alter the harvest of birds, fish and mammals	Yes	Valid; no changes in wording necessary
24	Industrial activities in harvesting areas will reduce the harvest of mammals, birds and fish because of conflicts between industry and harvesters over land use	Yes	Valid on local basis, especially for trapping; no changes in wording required
25	Increases in hunting by non-locals will restrict harvest by local natives	Yes	Valid; no changes in wording necessary

3.5.3 Additional Issues

The two primary additional issues that must be addressed during BREAM are major oil spills and community-based environmental concerns, although a number of other potential concerns were identified by participants during the planning meeting.

3.5.3.1 Major Oil Spills

A substantial amount of effort has been directed at major (catastrophic, worst-case) oil spills in the Beaufort Sea over the past few months due to work completed by various Task Groups of the Beaufort Sea Steering Committee. The final reports of each group should be reviewed by the BREAM core group before proceeding further in the project because these documents contain areas of recommended research and may also assist in the formulation of new impact hypotheses. Impact hypotheses should be developed around both an offshore well blowout and a pipeline rupture, and include an assessment of the associated response and countermeasure activities. It was also suggested that BREAM focus on "worst-case" events in order to anticipate probable EIRB assessment requirements.

3.5.3.2 Community-Based Environmental Concerns

Community-based concerns may form a component of all of the original BEMP and MEMP hypotheses that should be re-evaluated during BREAM (Tables 2 and 3). Meeting participants noted that quality of subsistence food will continue to be an important issue in the north, including potential effects unrelated to oil and gas development, such as effluent from the ALPAC pulp mill. Other contemporary issues will be the aesthetic impact (e.g., noise) of industrial development on the expected increase in tourism and economic diversification of the region.

3.5.3.3 Other Concerns

Various additional issues that may have to be addressed through BREAM were raised during the planning meeting. Some of these such as noise from gas processing facilities are expected to be very site-specific, while others such as global climate change and cumulative impacts of development are broader issues and would have to be evaluated as new linkages in many of the existing BEMP and MEMP hypotheses. The following is a list of potential issues raised by one or more meeting participants.

- Global climate change will be an area of increasing concern, particularly in relation to degradation of permafrost and pipeline stability and the effects of changes in temperature and precipitation on the landscape and habitat of VECs. The fact that there may be international agreements dealing with greenhouse gases and the existence and requirements under the Green Plan were also mentioned.

- Cumulative impact assessment may require additional actions and linkages in several hypotheses, including those from activities unrelated to oil and gas development.
- The potential effects of noise from compressors at the Taglu Gas Plant on birds and mammals may need to be addressed through evaluation of a new impact hypothesis.
- Similarly, it may be appropriate to develop a new hypothesis to assess the effects of barge traffic in the Eskimo Lakes on belugas, birds and fish during construction of the Parsons Lake facilities.
- As indicated in Table 3, a new hypothesis should be developed to address above-ground gas gathering systems.
- While not a major issue relative to oil spills, the release of natural gas due to a pipeline rupture should be evaluated in terms of potential effects on local air quality.
- The much higher quantities of drilling muds (including oil-based formulations) associated with production drilling and the subsequent disposal of drilling wastes will likely be an issue that needs to be evaluated.
- The scope of many of the existing MEMP impact hypotheses shown in Table 3 should probably be expanded to include all birds alon with terrestrial mammals, as well as their habitat, rather than just waterfowl.
- Similarly, mitigation and the success of mitigative measures should be explicitly considered during the evaluation of each impact hypothesis because assessment will be an integral part of BREAM, and "mitigatable with known technology" should be one of the possible conclusions that can be reached by future workshop participants.

3.6 ACTION PLAN FOR BREAM

The remainder of this section discusses the actions and activities that should be undertaken during the 1991/1992 fiscal year to move BREAM from the planning phase to an operational mode.

3.6.1 Creation of Steering Group

BEMP and MEMP were directed by a Steering Group. There is a similar need to create a Steering Group (Core Group) to coordinate BREAM activities, promote the program within the communities (government/regulatory, scientific, northern) described earlier, and ensure that each step and task in the process is completed as planned. The composition of the Steering Group was not discussed but probably should include representatives from government, industry, the Joint Secretariat, and perhaps the private sector. Project management and liaison would be the two primary responsibilities of this group. It was also suggested that the Steering Group would need to develop a list of BREAM sub-projects that should be started as soon as possible, and prepare the necessary Requests for Proposals.

The Steering Group would also be responsible for preparation and distribution of periodic "Announcements". The first of these should be prepared as soon as possible and identify who is involved in BREAM, what is its fundamental objective, and what activities are planned over the next year. If possible, this first Announcement should accompany the present Final Report of the Planning Phase.

3.6.2 Creation of Technical Working Groups

Three Technical Working Groups should be established by the Steering Group in the summer of 1991 to undertake the work necessary as a precursor to any project workshops. Liaison between the Chairperson of each Working Group and the Steering Group should occur on a regular basis to ensure that the products of these technical groups are prepared in a timely fashion and the entire project remains on track. The primary responsibility of the Technical Working Groups will be to determine which issues should be addressed in future workshops and identify who should participate in each workshop. In addition, they may have to prepare Background Papers and Literature Reviews for subsequent distribution to workshop participants. The latter would be reviewed by the Steering Group prior to release.

The composition of these Technical Working Groups was not discussed in detail during the Planning Meeting, although representatives of industry, government and the private sector would likely be present in each group. One of the groups will also have to have strong representation from the IFA structures and northern communities. It is also possible that some members of the Task Groups of the Beaufort Sea Steering Committee could play a significant role in the BREAM Technical Working Groups.

3.6.2.1 Review of Existing Impact Hypotheses

One Technical Working Group should be charged with the responsibility of reviewing each of the existing BEMP and MEMP impact hypotheses to be re-evaluated as part of BREAM. This will involve: (1) review of the Project Overviews presented in Section 5.1 and 5.2 of this report to determine how recent research is relevant to specific linkages for each hypothesis; (2) revision of the wording of some hypotheses to reflect the recommendations made in the Planning Meeting; and (3) alteration and addition of any linkages to reflect the above changes and to consider other issues such as cumulative impacts and global warming, when and where appropriate. In addition, this group will begin to select the participants necessary to properly evaluate each hypothesis in future workshops and make these recommendations to the Steering Group.

This Technical Working Group may also be in a position to develop some of the new or spin-off (from existing hypotheses) impact hypotheses recommended in the Planning Meeting, other than those addressing major oil spills and community-based environmental concerns. These new hypotheses would also be submitted to the Steering Group for review.

3.6.2.2 Catastrophic Oil Spill Background Information

This Technical Working Group will have a larger number of tasks to complete than the Existing Impact Hypotheses Technical Working Group. These tasks could include all or a portion of the following:

- Review of the Beaufort Sea Oil Spill Co-op simulation model to determine how it can best be incorporated with BREAM and presented at a project workshop.
- Preparation of an "Oil Spill Modelling Primer" discussing the above model and how various changes in input parameters influence the fate, trajectory and zone of influence of spills in open water and in ice-covered offshore areas.
- Review of all relevant final reports of the BSSC to determine the most appropriate scenarios to evaluate as part of BREAM, effectiveness of countermeasures, possible mitigation and habitat restoration techniques that should be assumed for the scenarios, etc.
- Development of one or more new impact hypotheses to assess the effects of an offshore well blowout and oil pipeline rupture into the Mackenzie River (including effects of countermeasures).
- Preliminary selection of participants who should attend workshops to evaluate the above impact hypotheses.

All of the products of this working group would be submitted to the Steering Group for review and approval prior to distribution to a wider audience.

3.6.2.3 Community-Based Environmental Concerns

This third Technical Working Group should include representatives of the IFA structures and northern communities. It will have numerous tasks to complete throughout the 1991/1992 BREAM project. One of the most important of these responsibilities will be the selection of issues that can be adequately addressed by BREAM and those which should be explicitly excluded (e.g., social issues). It was stressed during the Planning Meeting that it would be presumptuous of BREAM to try and address the social issues that exist in northern communities. Emphasis must be placed on the environmental concerns of these communities. It is, therefore, essential that community representatives participate in all aspects of the project in an ongoing manner and that feedback to the communities occurs on a regular basis.

3.6.3 Determination of Assessment Methodology

As environmental assessment will be an integral part of BREAM, it is important that the selected methodology be satisfactory to all the end-users of its products. It should also comply with any legislative requirements and procedures considered appropriate by those agencies that will be involved in the review of future project applications. To the extent possible, it should also be semi-quantitative and lead to defensible conclusions on the significance of potential impacts of hydrocarbon development and transportation in the region.

Selection of an appropriate assessment methodology was not discussed at the Planning Meeting. Therefore, the Steering Group and the Chairpersons of each of the three Technical Working Groups should meet at the outset of the 1991/1992 program to select a procedure that will satisfy everyone's needs. It is also important that this procedure be relatively efficient and practical for use in a workshop environment.

3.6.4 Liaison to Develop Support

The primary responsibility for liaison throughout BREAM should remain with the Steering Group. Liaison to develop support for the program should occur with federal and territorial government agencies, other regulatory bodies such as the EIRB, the IFA structures, similar organizations and HTAs along the proposed pipeline corridor (e.g., Dene-Metis Association), and the oil and gas industry and pipeline companies involved in the Joint Venture. It was suggested that considerable effort will be necessary to convince northern communities of the value of BREAM, and that much of the liaison will have to be through the IFA structures. It will also be important to take the first steps in bringing traditional knowledge to the process to help ensure its success and acceptability to the communities.

3.6.5 Program Announcement and Updates

As indicated in Section 3.6.1, the Steering Group should prepare a Program Announcement as well as various Program Updates at key points during the project. These products should be brief but informative and written in a non-technical style to ensure that they can be understood by a wide audience. They will also need to be easily translatable.

3.6.6 Workshops in 1991/1992 Fiscal Year

The number of workshops that may be necessary in the second year of BREAM was not discussed in the Planning Meeting. Arguments were presented in favour of one large workshop to re-visit all of the existing BEMP and MEMP impact hypotheses, but this may not be very practical given the size of the group required and associated logistical constraints. It was also suggested that it may be necessary to have pre-workshop meetings prior to any full workshop to address community-based environmental concerns. It was stressed that the BREAM Steering Group and Technical Working Groups should not hesitate to rely on expertise from outside Canada.

The following four workshop topics may be appropriate given the large technical scope of BREAM:

- Offshore Assessment (existing BEMP hypotheses)
- Onshore Assessment (existing MEMP and new hypotheses)
- Community-Based Concerns Workshop (held in the north)
- Major Oil Spills (2 groups, dealing with offshore blowout and pipeline rupture)

LITERATURE CITED

Bush, M. 1990. Public participation in resource development after project approval. Canadian Environmental Assessment Research Council. 29 p.

4. BEAUFORT SEA INFORMATION DATABASE REQUIREMENTS

4.1 INTRODUCTION

This report section summarizes the results of a workshop conducted on 17-18 January 1991 in Calgary to discuss Beaufort Sea Information Database Requirements (see Appendix B for List of Participants). The workshop objective was to examine the sufficiency of existing databases to enable the Environmental Impact Review Board (EIRB) to review offshore drilling proposals relative to its IFA mandate (i.e., wildlife harvesting and compensation as specified in Sections 11 and 13 of the IFA). Part III of the Final Report of Task Group No. 4 (Research and Science) to the Beaufort Sea Steering Committee also presented a summary of the discussions and conclusions of this workshop. David Thomas and Wayne Duval of the Seakem Group Ltd. were the workshop facilitator and rapporteur, respectively.

4.1.1 Background to Workshop

The EIRB identified information database deficiencies relating to impact assessment, countermeasures and contingency planning as one of the factors contributing to its decision to recommend that the Kulluk drilling program not be approved. The specific recommendation from the Kulluk review is presented below.

Kulluk 6: An independent task force must be established to examine the research, management and funding requirements necessary to ensure that the information database is in place to facilitate environmental impact assessment and countermeasures and contingency planning, relating to an offshore oil spill in the Beaufort Sea.

The Board further suggested (Kulluk 2) that all oil spill contingency plans should include oil spill countermeasure plans, oil spill clean-up plans and oil spill related wildlife protection plans. It cited the following examples of missing information in the material included in Gulf's application:

- identification of sensitive areas;
- protection plans for particularly sensitive species;
- plans for shoreline protection and clean-up;
- remedial measures designed to protect valuable wildlife[1] likely to be exposed to oil;
- the extent to which these wildlife species would be sensitive to this exposure;
- the ability to identify priorities in protection efforts, and equipment and support required; and
- effects of a spill response on wildlife populations and resource harvesting.

In making its recommendations, the EIRB disagreed with the proponent's belief that "there does not exist a reliable body of information to enable it to provide the Board with any estimates, assumptions, models, or data on the crucial areas of shoreline impacts, shoreline response, and clean-up standards". Accordingly, the EIRB concluded that "there is, based on the evidence and information presented at this Public Review, an urgent need to develop an up-to-date database to support oil spill assessment, countermeasures and contingency planning".

[1] NOTE: The term "wildlife" is used in this report section in the same context as in the Inuvialuit Final Agreement and includes all resources harvested or potentially harvested in the region.

4.1.2 Workshop Scope

The January 1991 workshop focused on determination of the following:

- the status of the information database necessary for the purpose of environmental assessment of oil spills and contingency planning (defined by the EIRB to include countermeasures, clean-up and wildlife protection);
- the status of the available database itself, rather than any computerized information database (i.e., the concern is whether the information is available to allow the EIRB to make an informed recommendation to the regulatory authority and not with the form of that information);
- the opportunities for gathering the type and quality of data necessary for informed decisions by the EIRB (as specified in IFA Sections 11 and 13) as opposed to data for either scientific or regulatory mandate purposes;
- what data are actually needed and what can be done with the information on hand, rather than simply what are the known data gaps (i.e., the key question is what do we **need** to know rather than what do we **not know**); and
- the categorization of database needs identified by the EIRB into those which are obtainable and those which could only be obtained as a result of a scientific response to an actual oil spill.

The following boundaries on the scope of the discussions and information database assessment were agreed upon by workshop participants:

- only those oil spills which could occur in the offshore Beaufort Sea were considered (vs. onshore spills affecting either terrestrial or aquatic habitats);
- an oil spill could occur at any time of the year and from any source;
- the geographic boundaries of the region where the sufficiency of information databases was to be evaluated was to include the Inuvialuit Settlement Region; and

- the landward limit of the Beaufort offshore was defined as the storm surge line.

4.1.3 Definitions

A series of definitions were tabled at the January 1991 workshop to help focus discussions in relation to the expected information requirements of the EIRB.

CONTINGENCY PLAN: should include oil spill countermeasures plan, oil spill clean-up plans, and oil spill-related wildlife protection plans (after EIRB; Kulluk 2).

MARINE COUNTERMEASURES PLAN: the containment and recovery of "mobile" oil on water and the protection of shoreline areas, ice edges, leads, etc.

SHORELINE CLEAN-UP PLAN: the removal, recovery and disposal of oil after it is no longer mobile, from shorelines and intertidal areas.

WILDLIFE: wildlife includes those biological resources as specified in the Inuvialuit Final Agreement.

WILDLIFE PROTECTION PLAN: should include a consideration of deterrent use, relocation of wildlife, habitat protection, and the cleaning and treatment of oil-contaminated wildlife.

WILDLIFE HABITAT RESTORATION: restoration is the accelerated functional return of habitat to a pre-spill or normal state to the extent practicable.

ENVIRONMENTAL ASSESSMENT (in the IFA context): the process whereby one predicts the potential direct and indirect effects of an oil spill and the impact on present and continuing harvest opportunities and/or success.

4.1.4 Framework for Assessing Information Requirements

The following table was developed to focus the workshop discussions on what we need to know and whether the existing information database is sufficient.

CONTINGENCY PLAN

	Marine Counter-measures Plan	Shoreline Clean-up Plan	Wildlife Protection Plan	Wildlife Habitat Restoration	Environ. Impact Assessment
HARVEST					
MAMMALS					
BIRDS					
FISH					

For each box in this matrix of information database needs, the following questions were asked and decisions made.

1. What do we need to know and why?
2. Is there adequate information? If not, what essential information is missing?
3. If missing and essential, what should/can be done to provide information? The following decisions should then be made:
   - (a) acquire the new information;
   - (b) use a surrogate; or

(c) not possible to acquire the information (inadequate prospects for success, too expensive, etc.).

4.2 SUMMARY OF INFORMATION NEEDS

Many of the information requirements for contingency plans, wildlife habitat restoration, and environmental impact assessment are expected to be similar within the broad categories of harvest, resource (species), and physical/other information. The depth of information needed, however, may vary substantially depending on its intended use. Table 4 provides a summary of general information needs discussed during the workshop.

4.3 MARINE COUNTERMEASURES PLAN

Database requirements related to countermeasures include information on: effects, effectiveness, and logistics (availability and deployment). The highest priority in terms of effects information required is the vulnerability and sensitivity of species, both to oil and to various countermeasures techniques. However, the requirement for this information is in a relative sense (i.e., species vs. species) to allow informed prioritization of countermeasures techniques and application. Consequently, a lower level of information is required for countermeasures than that required for environmental impact assessment.

TABLE 4
SUMMARY OF INFORMATION REQUIREMENTS

	CONTINGENCY PLAN				
INFORMATION	Marine Countermeasures Plan	Shoreline Clean-up Plan	Wildlife Protection Plan	Wildlife Habitat Restoration	Environmental Impact Assessment
HARVEST	* Locations * Times * Relative Importance of Species	* Locations * Times * Relative Importance of Species	* Locations * Times * Relative Importance of Species	* Locations * Times * Harvest levels * Catch per unit effort	* Locations * Times * Harvest levels * Catch per unit effort
SPECIES	* Abundance * Distribution * Pop dynamics * Critical habitats and life history * Concentration areas, timing and movements * Vulnerability to oil exposure * Sensitivity to oil and countermeasures	* Abundance * Distribution * Pop dynamics * Critical habitats and life history * Concentration areas, timing and movements * Vulnerability to oil exposure * Sensitivity to oil and countermeasures	* Abundance * Distribution * Pop dynamics * Critical habitats and life history * Concentration areas, timing and movements * Vulnerability to oil exposure * Sensitivity to oil and countermeasures	* Abundance * Distribution * Pop dynamics * Critical habitats and life history * Concentration areas, timing and movements * Sensitivity to oil and countermeasures	* Abund/Distrib * Pop dynamics * Crit. habitats and life history * Concentration areas, timing, movements * Vulnerability to oil exposure * Sensitivity to oil, c-measures * Recovery Potential
PHYSICAL AND OTHER	* Oil behaviour and fate * Project description * Climate, waves, currents, etc. * Available countermeasures and their effectiveness * Logistical constraints and opportunities * Financial limitations	* Oil behaviour and fate * Project description * Climate, waves, currents, etc. * Available countermeasures and their effectiveness * Logistical constraints and opportunities * Financial limitations	* Oil behaviour and fate * Project description * Climate, waves, currents, etc. * Available countermeasures and their effectiveness * Logistical constraints and opportunities * Financial limitations * Reporting Structure * Specialist and Supplier lists * Prioritization of protection techniques	* Oil behaviour and fate * Project description * Climate, waves, currents, etc. * Available habitat restoration measures, their effectiveness and potential impacts * Logistical constraints and opportunities * Financial limitations	* Oil behaviour and fate * Project description * Climatic conditions * Available countermeasures and their predicted efficiency * Logistical constraints * Process, scope and definition of terms under the IFA * Methodology for assessing potential impacts

From a marine countermeasures perspective, the information **database is probably sufficient** to allow informed decision-making with respect to all wildlife species, and no critical information need is evident.

Marine countermeasures information is required primarily as the means for setting priorities for countermeasures response. Because decisions on the selection of countermeasures are made quickly and often with a limited amount of information on hand, it is advisable that a framework be developed and in place prior to a spill to facilitate this decision-making process.

There have been numerous investigations of the effects of countermeasures, and this surrogate information is generally transferable to the Beaufort Sea. Nonetheless, there is recognition that there may not be sufficient regional information in all cases to justify public policy and particularly to justify only a measured or limited response to a spill. This should be considered in determining the sufficiency of the information database.

4.4 SHORELINE CLEANUP PLAN

Discussion of this element of contingency plans centred on whether there is sufficient information to determine the net environmental effect of various clean-up techniques, and enough information to make the decision of "how clean is clean". It is fair, but not particularly helpful, to state that priorities for clean-up will be assigned based on political, socio-economic, scientific and logistic considerations; oil will be cleaned up so long as there is a net benefit in doing so. The question of "how clean is clean" remains an important but unresolved issue.

The database is available to set priorities for critical areas of harvested and sensitive species such as polar bears and birds. The information contained in the Beaufort Sea Oil Spill Atlas (Dickins *et al*. 1987) is being augmented now by valuable additional work by Ed Owens (Woodward-Clyde Consultants Inc.) designed to set priorities and discuss logistics and personnel requirements for clean-up of the Beaufort Sea shoreline. Taken together, these information sources will address many of the concerns related to clean-up preparedness. Other issues such the location of oil storage and disposal sites and the long-term fate of oil in some beach types are not adequately resolved and should be examined further.

It is agreed that there is a general scarcity of information on the effects of clean-up techniques and that such data collection should receive high priority when the opportunity presents itself (i.e., "spills of opportunity"). This should be identified as part of a scientific spill response plan which prioritizes the information to be collected following a spill.

Many of the information needs identified in Table 4 cannot be obtained without an actual oil spill. This leaves two options: (1) opportunistic studies conducted during the scientific response to a spill; (2) or an experimental oil spill. The latter option was considered viable and worthy of further consideration, but was not addressed further in the workshop. Participants concluded that there is a clear need to develop a work plan for actual or experimental spills, and recommended that some other group initiate this activity, perhaps as part of BREAM.

4.5 WILDLIFE PROTECTION PLAN

The priority in the implementation of the elements of any oil spill response plan should be to: (1) **deter** wildlife/biota to prevent or at least minimize contact with oil; (2) **protect** wildlife/biota in areas where oil exposure is probable; and (3) **clean** those wildlife/biota that become contaminated with oil.

(1) Deterrents

There are a number of reasons why the need for information on deterring mammal species is not great: considerable information is available (e.g., with polar bears and caribou); deterrent techniques may be impractical because of the species distribution and habits (e.g., seals); or the overall population is not considered highly vulnerable to oil (e.g., whales, Arctic foxes). Although deterrents could, in some cases, be employed with these species, it was concluded that the priority for obtaining additional information is not high.

The information database pertinent to deterring birds in the Beaufort Sea is limited. However, surrogate information is available for other regions and should be reviewed and summarized to help evaluate the potential success and effectiveness of these techniques in the Beaufort Sea. It was noted that an ongoing ESRF-funded study will help to determine if field testing of bird deterrent techniques in the Beaufort Sea is warranted.

(2) Protection of Habitat

Considerable attention has been directed to identification of priority areas for clean-up and the database for the region is generally adequate (e.g., Dickens *et al.* 1987; ongoing work of Ed Owens). However, an information need is identified with respect to the location of both "permanent and temporary" waste storage sites. Efforts should be made to expand the criteria for the selection of sites to include not only physical criteria (e.g., topography, protection from storm surges, permafrost distribution) but also logistical (e.g., access to pickup) and socio-economic considerations. This would assist teams which must make real-time decisions in the event of a spill, such as the Spill Clean-up and Assessment Teams (SCAT) employed following the EXXON VALDEZ spill.

(3) Cleaning and Treating Oiled Individuals

This subject was considered an issue primarily for birds and bears. The information database on the cleaning and treatment of oil-contaminated birds is large and sufficient, although there is some value in re-examining the transferability of information from other areas (particularly Alaska and the North Atlantic region). There is also opportunity to improve the database for polar bears (and grizzly bears) through relatively simple and non-controversial testing of the effectiveness of cleaning agents on bear pelts. Such work could supplement the results of previous studies (e.g., Oristland *et al.* 1982) by using a more representative oil such as Amauligak crude and a wider range of cleaning agents.

4.6 WILDLIFE HABITAT RESTORATION

This subject has been addressed in considerable detail in the BSSC Task Group 2 Final Report. The existing information database on the effects and effectiveness of restoration techniques (e.g., bioremediation, revegetation, habitat enhancement) is poor. In the event of a spill, collection of this information should receive a high priority.

In the IFA context, the restoration requirement is to "return the habitat as far as practicable to its original state". Restoration could be used to accelerate natural recovery and to achieve productive capability of wildlife habitat. There is considerable basic ecological information available to measure such recovery but it is neither practical, nor financially realistic, to determine the existing productive capacity of Beaufort Sea coastal habitats. It may be possible, however, to focus on the reproductive capacity of the two most important species from a harvesting perspective (polar bears and beluga) and/or to focus on key or indicator species (e.g., red-throated loons).

Workshop participants suggested that BREAM could be used to determine the ecological information database necessary to predict and measure restoration success. It could also use the hypotheses/linkage approach as a means of determining what ecological information is sufficient and what new information is necessary.

4.7 ENVIRONMENTAL ASSESSMENT

The issue of environmental assessment methodology is addressed in detail in the Beaufort Sea Steering Committee Task Group 4 Final Report on Kulluk Recommendation #7. Some key points made during the information database workshop are presented below.

At the outset of this discussion, the distinction was made between environmental assessment and damage appraisal. The latter involves the verification of a pre-spill prediction that might occur during a scientific response to an actual spill and was considered outside the scope of the present workshop.

The database required for environmental assessment (EA) is generally more comprehensive and more detailed than that required for effective contingency planning or restoration. As stated in the earlier definitions (Section 4.1.3), environmental assessment in the IFA context focuses on potential impacts on present and continuing wildlife harvesting opportunities. Any ecological linkage, therefore, must be tied directly to harvest. Environmental assessments completed for the purpose of the IFA also differ from the mandate-related EA required under the EARP Guidelines Order; the latter necessitate determination of the "significance" of potential project impacts, as well as consideration of alternatives. In assessments completed under the IFA, the evaluation of "significance" becomes the responsibility of the Environmental Impact Screening Committee and EIRB.

The IFA assumes the "worst case" on which to base estimates of financial liability. However, the environmental assessment should, in order to be realistic, assume some degree of success in mitigation (e.g., relief well capabilities, marine countermeasures, etc.). The potential success of this mitigation should be predicted by the proponent and independently assessed by the Government authority.

Any environmental assessment methodology should allow at least semi-quantitative predictions to the extent possible. The methodology should also demand clean documentation or an "audit trail" of assumptions and judgements. The ongoing work undertaken co-operatively for Gulf Canada and the Department of Fisheries and Oceans by ESL Environmental Sciences Limited since the Kulluk and Isserk EIRB hearings was noted as a promising methodology which allows the "expert" to better document and quantify predictions.

There should be a conscious change in focus towards what are bonafide data needs as opposed to weak links and data gaps. The latter cycle can be endless in that regardless of the sufficiency of the information, there will always be weak links. The focus, therefore, should shift from what we don't know to what we need to know.

Workshop participants were able to recommend several "candidate areas" for further research such as the distribution and critical habitats of eiders in the spring and fall. It was agreed that these candidates should be further assessed and refined in a process which uses impact hypotheses, linkages and a more rigorous and detailed determination of the adequacy of existing information. The Beaufort Environmental Monitoring Program (BEMP) was successful in this task but did not consider the catastrophic oil spill scenario; this task should be undertaken as part of BREAM.

Other areas that may be evaluated as part of BREAM in relation to the sufficiency of information for assessment purposes include oil behaviour and fate, particularly how trajectory analyses and zones of influence calculations are influenced by oil type and characteristics and assumed physical environmental conditions. The weathering characteristics of Amauligak crude may also be another area where further research is justified, including changes in oil behaviour that may result from the burning of oil on the water surface. There was also considerable discussion of whether averages rather than worst-case assumptions should be used during such modelling exercises. Arguments were presented in support of both approaches and it was recommended that the EIRB and regulators be canvased as part of BREAM to determine their expectations.

It was also suggested that prior to future BREAM workshop approaches, it would be valuable as a scoping exercise to develop a "super table" which identifies the sensitivity and vulnerability of all wildlife species or species groups identified in Dickens *et al.* (1987). The table should also include a statement regarding the state of the biological database and include information on the species distribution and abundance as well as reproductive capacity. It should also be accompanied by a detailed audit trail.

LITERATURE CITED

Dickins, D., L. Martin, I. Bjerkelund, S. Potter, D. Erickson, J. Harper, P. Norton, S. Johnson and P. Vonk. 1987. Environmental Atlas for Beaufort Sea Oil Spill Response. Prep. by DF Dickins Associates and ESL Environmental Sciences Limited for Environmental Protection Service, Environment Canada, Yellowknife. 182 p.

Oristland, N.A., F.R. Engelhardt, F.A. Juck, R.A. Hurst and P.D. Watts. 1982. Effect of crude oil on polar bears. Environmental Studies No. 24, Northern Affairs Program, Department of Indian Affairs and Northern Development, Ottawa.

APPENDIX A
PARTICIPANTS IN BREAM PLANNING MEETING
Chateau Airport, Calgary, 19-20 March 1991

NAME	AFFILIATION
Bob Bell	Fisheries Joint Management Committee
Marty Bergmann	Department of Fisheries and Oceans
Dave Bernard	ESSA Environmental and Social Systems Analysts Ltd.
Evan Birchard	Esso Resources Canada Ltd.
Bob Buchanan	LGL Limited
Rolph Davis	LGL Limited
Lynne Dickson	Environment Canada, Canadian Wildlife Service
Wayne Duval	ESL Environmental Sciences Limited
Rick Hurst	Indian and Northern Affairs Canada
Steve Johnson	LGL Limited
Gordon Koshinsky	Department of Fisheries and Oceans
Michael Lawrence	North/South Consultants Inc.
Harvey Martens	Hardy BBT Limited
Rob Owens	Foothills Pipelines Ltd.
Ted Spearing	Chevron Resources Canada Ltd.
David Thomas	Seakem Oceanography Ltd.
Walt Younkin	Hardy BBT Limited

APPENDIX B
PARTICIPANTS IN BEAUFORT SEA INFORMATION DATABASE REQUIREMENTS WORKSHOP
The Delta Bow Valley, Calgary, 17-18 January 1991

NAME	AFFILIATION
Terry Antoniuk	Gulf Canada Resources Limited
Marty Bergmann	Department of Fisheries and Oceans
Evan Birchard	ESSO Resources Canada Ltd.
Bill Brakel	Environment Canada
Larry de March	Department of Fisheries and Oceans
Peter Devenis	Gulf Canada Resources Limited
Lynne Dickson	Environment Canada, Canadian Wildlife Service
Wayne Duval	ESL Environmental Sciences Limited
Manfred Hoeffs	Yukon Government
Rick Hurst	Indian and Northern Affairs Canada
Michael Lawrence	North/South Consultants Inc.
Doug Mathews	Government of the Northwest Territories
George McCormick	Canada Oil and Gas Lands Administration
Gary Sergy	Environment Canada
Brian Smiley	Department of Fisheries and Oceans
David Thomas	Seakem Oceanography Ltd.
John Ward	Amoco Canada Petroleum Ltd.

5. RESEARCH OF RELEVANCE TO BREAM

An important aspect of the 1990-1991 BREAM project was to review the results of research initiated or completed since 1987 when the last evaluation of this type occurred. This task focused on studies that: (1) are known to be relevant to one or more of the existing BEMP and MEMP impact hypotheses; (2) are expected to provide the necessary background for definition of those hypotheses which will focus on community-based socio-economic concerns; and (3) will assist in the development and assessment of impact hypotheses related to major oil spills in the Beaufort region. Discipline specialists from a number of companies conducted the review of relevant research. The specific disciplines are identified in the following table.

DISCIPLINE SPECIALTY	PERSON	AFFILIATION
Chemical Oceanography	David Thomas	Seakem Oceanography Ltd.
Hydrocarbon Chemistry, Fate and Effects	Paul Erickson	Seakem Oceanography Ltd.
Oil Spills	Patricia Vonk	ESL Environmental Sciences Limited
Physical Oceanography	Dave Fissel	Arctic Sciences Ltd.
Birds	Steve Johnson	LGL Limited
Marine Mammals	Rolph Davis	LGL Limited
Lower Trophic Levels	Bob Buchanan	LGL Limited
Fish	Mike Lawrence	North-South Consultants Ltd.
Coastal Processes	John Harper	Harper Environmental Services Ltd.
Terrestrial Mammals	Jeff Green	Delta Environmental Management Group Ltd.
Vegetation and Terrain	Harvey Martens	Hardy Associates BBT Ltd.
Socio Economic Issues	Bob Steph[illegible]	Lutra Associates Ltd.

The tables presented on the following pages provide an index of all of the studies that were reviewed by the project team as part of this planning phase of BREAM. The "B" or "M" in the number indicates whether the research is discussed under the BEMP or MEMP Impact Hypotheses in Sections 5.1 and 5.2, respectively. Projects that were expected to be relevant to new hypotheses addressing oil spills are proceeded with "OS". Where an investigation is relevant to more than one existing BEMP or MEMP hypothesis or further hypotheses, this is indicated below the number in the form B-x or M-x, where "x" refers to the hypothesis number.

INDEX OF PROJECT OVERVIEWS

NUMBER	PRINCIPLE INVESTIGATOR(S) AFFILIATION(S)	TITLE	PAGE
B1-1	R.W. Macdonald Institute of Ocean Sciences, DFO	Beaufort Sea oceanography	85
B1-2	D. Fissel and M. Bradstreet Arctic Sciences Ltd. and LGL Ltd.	Beaufort Sea zooplankton distributions, 1987	86
B1-3 B3,6,16,20 M11,16	R.W. Macdonald Institute of Ocean Sciences, DFO	The distribution of nutrients in the southeastern Beaufort Sea: implications for water circulation and primary production	87
B1-4 B3,6,16,20 M11,16	T.R. Parsons University of British Columbia	Production studies in the Mackenzie River-Beaufort Sea Estuary	88
B1-5 B3,6,16,20 M11,16	A.D. Sekerak LGL Limited	Ecological factors governing the distribution and abundance of the copepod, *Limnocalanus macrurus*, in the Beaufort Sea	90
B1-6 B3,6,16,20 M11,16	M.S.W. Bradstreet LGL Limited	Zooplankton and bowhead whale feeding in the Canadian Beaufort Sea, 1986	92
B1-7 B3,6,16,20 M11,16	M.S.W. Bradstreet LGL Limited	Zooplankton of a bowhead whale feeding area off the Yukon coast in August 1985	94
B1-8	W.J. Richardson LGL Limited	Importance of the eastern Alaska Beaufort Sea to feeding bowhead whales, 1985	95
B1-9	W.J. Richardson LGL Limited	Importance of the eastern Alaskan Beaufort Sea to feeding bowhead whales, 1985-86	97

INDEX OF PROJECT OVERVIEWS (Page 2)

NUMBER	PRINCIPLE INVESTIGATOR(S) AFFILIATION(S)	TITLE	PAGE
B1-10 B3,6,16,20 M11,16	Various Arctic Sciences Ltd. and LGL Ltd.	Zooplankton distributions in the southeastern Beaufort Sea, summer 1987	99
B1-11 B3,6,16,20 M11,16	A.D. Sekerak LGL Limited	Distribution and life history of *Limnocalanus macrurus*, an estuarine copepod, in the Beaufort Sea	101
B1-12	R.A. Davis, W.R. Koski, G.W. Miller LGL Limited	Experimental use of aerial photogrammetry to assess the long-term responses of bowhead whales to offshore industrial activities in the Canadian Beaufort Sea, 1984	102
B1-13	R.A. Davis, W.R. Koski, G.W. Miller LGL Limited	Reproduction in the bowhead whale, summer 1985	105
B1-14	P.R. Miles, C.I. Malme, G.W. Shepard, W.J. Richardson, J.E. Bird BBN Laboratories and LGL Limited	Prediction of drilling site-specific interaction of industrial acoustic stimuli and endangered whales: Beaufort Sea (1985)	107
B1-15	P.R. Miles, C.I. Malme, W.J. Richardson BBN Laboratories and LGL Limited	Prediction of drilling site-specific interaction of industrial acoustic stimuli and endangered whales in the Alaskan Beaufort Sea	108
B1-16	R.A. Davis, C.R. Greene, C.R. Evans, S.R. Johnson, W.R. Koski, S.R. Johnson LGL Limited and Greeneridge Sci.	Responses of bowhead whales to an offshore drilling operation in the Alaskan Beaufort Sea, autumn 1986	110
B1-17 B21	W.R. Koski, G.W. Miller, R.A. Davis LGL Limited	The potential effects of tanker traffic on the bowhead whale in the Beaufort Sea	112
B1-18	J.G. Ward and E. Pessah Dome Petroleum Ltd.	Industry observations of bowhead whales in the Canadian Beaufort Sea, 1976-1985	116
B1-19	W.J. Richardson and K.J. Finley LGL Limited	Comparison of behaviour of bowhead whales of the Davis Strait and Bering/Beaufort stocks	117
B1-20	G.W. Miller, R.A. Davis, W.J. Richardson LGL Limited	Behaviour of bowhead whales of the Davis Strait and Bering/Beaufort stocks vs. regional differences in human activities	119
B1-21	D.M. Schell, S.M. Saupe, N. Haubenstock University of Alaska	Bowhead whale (*Balaena mysticetus*) growth and feeding as estimated by ∂^{13}C techniques	120

INDEX OF PROJECT OVERVIEWS (Page 3)

NUMBER	PRINCIPLE INVESTIGATOR(S)	TITLE	PAGE
B1-22 B21	D. Wartzok[1], W.A. Watkins[2], B. Würsig[3] and C.I. Malme[4] [1]Purdue Univ., [2]Woods Hole Ocean. Inst., [3]Moss Landing Mar. Lab. [4]BBN Systems and Technologies Corp.	Movements and behaviours of bowhead whales in response to repeated exposures to noises associated with industrial activities in the Beaufort Sea	122
B1-23 B21	[1]D. Wartzok, [2]W.A. Watkins, [3]B. Würsig, [4]J. Guerrero, [5]J. Schoenherr [1]Purdue Univ., [2]Woods Hole Ocean. Inst., [3]Texas A & M Univ., [4]Moss Landing Mar. Lab., [5]Univ. of Rhode Island	Movements and behaviour of bowhead whales	123
B1-24	D. Wartzok Purdue University	Industry-sponsored bowhead whale monitoring and research in the U.S. and Canadian Beaufort Sea	125
B1-25 B2,3,5,21	[1]C.I. Malme, [1]P.R. Miles, [2]G.W. Miller, [2]W.J. Richardson, [2]D.G. Roseneau, [2]D.H. Thomson, [3]C.R. Greene, Jr. [1]BBN Systems and Technologies Corp., [2]LGL Ltd., [3]Greeneridge Sci.	Analysis and ranking of the acoustic disturbance potential of petroleum industry activities and other sources of noise in the environment of marine mammals in Alaska	126
B1-26 B2-9,19 -21	W.J. Richardson, J.P. Hickie, R.A. Davis, D.H. Thomson, C.R. Greene LGL Limited and Greeneridge Sciences Inc.	Effects of offshore petroleum operations on cold water marine mammals: A literature review	128
B1-27 B2-8,21	W.J. Richardson[1], C.R. Greene Jr.[2], C.I. Malme[3] and D.H. Thomson[1] [1]LGL Limited, Greeneridge Sci. Inc.[2], BBN Systems and Technologies Corp.[3]	Effects of noise on marine mammals	130
B1-28	D.M. Schell, S.M. Saupe, N. Haubenstock, K. Vinette University of Alaska	Trophic investigations of the Arctic Ocean and Bering Sea via stable isotope analysis	131
B1-29 B2	W.J. Richardson[1], C.R. Greene[2], Jr., W.R. Koski[1], C.I. Malme[3], G.W. Miller[1], M.A. Smultea[4], B. Würsig[4] [1]LGL Limited, [2]Greeneridge Sci. Inc., [3]BBN Systems and Technologies Corp., [4]Texas A&M University	Acoustic effects of oil production activities on bowhead and white whales visible during spring migration near Pt. Barrow, Alaska – 1989 phase: Sound propagation and whale responses to playback of continuous drilling noise from an ice platform, as studied in pack ice conditions	133

INDEX OF PROJECT OVERVIEWS (Page 4)

NUMBER	PRINCIPLE INVESTIGATOR(S) AFFILIATION(S)	TITLE	PAGE
B2-1 B3,4,5,6	R. Frederking, D. Topham, H. Melling NRC and Institute of Ocean Sciences (DFO)	Beaufort Sea ice: morphology and dynamics	137
B2-2 B3,4,5,6	D. MacGillvery MEP Consultants	Impacts of climatic change on the Beaufort Sea ice regime	138
B2-3 B13 M23,24	Alex Aviugana Mackenzie Delta Beaufort Sea Regional Land Use Planning Com.	A draft community-based Regional Land Use Plan for the Mackenzie Delta-Beaufort Sea Region	139
B2-4 B8,13 M18,19, 21-25	M. Fabijan Joint Secretariat, Renewable Resource Committees	Inuvialuit harvest study	140
B2-5 B8,13 OS	D.F. Dickins[1] and L. Martin[2] [1]D.F.Dickins and Associates Ltd. and [2]ESL Environmental Sciences Limited	Environmental Atlas for Beaufort Sea Oil Spill Response	141
B2-6 M19	Anonymous EMR and INAC	The Canadian Oil and Gas Lands Administration, Annual Reports 1988 and 1989	142
B2-7 M18,19	Anonymous Unknown	Beluga harvest monitoring, 1988, 1989 and 1990	143
B2-8	S.E. Cosens and L.P. Dueck Freshwater Institute (DFO)	Responses of migrating narwhal and beluga to icebreaker traffic at the Admiralty Inlet ice-edge, N.W.T. in 1986	144
B3-1	K.J. Frost and L.F. Frost Alaska Dept. of Fish and Game	Effects of industrial activities on ringed seals in Alaska, as indicated by aerial surveys	148
B3-2	B.P. Kelly, J.J. Burns, L.T. Quakenbush Univ. of Alaska and Living Resources Inc.	Responses of ringed seals (*Phoca hispida*) to noise disturbance	149
B3-3	L.A. Harwood University of Alberta	Distribution of ringed seals in the southeast Beaufort Sea during late summer	151
B3-4 B4,5	[1]S.R. Johnson, [2]J.J. Burns, [3]C.I. Malme, [1]R.A. Davis [1]LGL Alaska Research Associates, Inc., [2]Living Resources Inc., [3]BBN Systems and Technologies Corp.	Synthesis of information on the effects of noise and disturbance on major haulout concentrations of Bering Sea pinnipeds	152

INDEX OF PROJECT OVERVIEWS (Page 5)

NUMBER	PRINCIPLE INVESTIGATOR(S) AFFILIATION(S)	TITLE	PAGE
B4-1 B6	H. Melling and P. Budgell Institute of Ocean Sciences (DFO)	Beaufort Sea ice motion program	157
B6-1	R. Crawford Freshwater Institute (DFO)	Arctic cod distribution, abundance and vulnerability to perturbation	163
B6-2 B19	M. Bergmann Freshwater Institute (DFO)	Mackenzie Shelf fisheries habitat research	164
B6-3 B7-9,20	Jack W. Lentfer (workshop convener) Independent Consultant	Workshop on measures to assess and mitigate the adverse effects of Arctic oil and gas activities on polar bears	165
B10-1 B13,20	S. Blasco, D. Forbes, R. Taylor, S. Dalmar, P. Hill Atlantic Geoscience Centre, Geol. Survey of Canada	Nearshore sediment transport and dynamics	176
B10-2 M11 OS	J.F. Piatt, C.J. Lensink, W. Butler, M. Kendziorek, D.R. Nysewander Alaska Fish and Wildl. Serv., Alaskan Dept. of Environ. Cons., Alaska Marit. Nat. Wildl. Refuge	Immediate impact of the EXXON VALDEZ oil spill on marine birds	177
B10-3 M7,8,10	Unknown Canadian Wildlife Service	Banks Island Bird Sanctuary No. 1. Management Plan	179
B10-4 M7,10	J.E. Hines Canadian Wildlife Service	Progress report: surveys of geese and swans in the Inuvialuit Settlement Region, 1989	180
B10-5 M7,10	A. Reed Canadian Wildlife Service	Segregation of Brant Geese *Branta bernicla* wintering and staging in Puget Sound and the Strait of Georgia	181
B10-6 M10, OS	W.E. Cross LGL Limited	Wildlife and wildlife habitat restoration in the event of an oil spill in the Beaufort Sea	182
B10-7 M7,10	S.A. Alexander Canadian Wildlife Service	Spring migration of eiders, oldsquaws and glaucous gulls along offshore leads of the Canadian Beaufort Sea	185
B10-8 M7,10	J. Sirois Canadian Wildlife Service	The avifauna of Toker Point, Tuktoyaktuk Peninsula, Northwest Territories, 1985-1987	187
B10-9 M7,10	D.M. Ealey Canadian Wildlife Service	Spring migration of eiders, oldsquaws and glaucous gulls along offshore leads of the Canadian Beaufort Sea	188
B10-10 M7,10	R.W. Cole Canadian Wildlife Service	Progress report on surveys of geese and swans in the Inuvialuit Settlement region, 1988	189

INDEX OF PROJECT OVERVIEWS (Page 6)

NUMBER	PRINCIPLE INVESTIGATOR(S) AFFILIATION(S)	TITLE	PAGE
B10-11 M7,10	R.H. Krebes Canadian Wildlife Service	International snow goose neckbanding project - progress report	191
B10-12 M7,10	R.H. Krebes Canadian Wildlife Service	Neckbanding of Arctic geese	192
B10-13 M7,10	S.J. Johnson and D.R. Herter LGL Alaska Res. Assoc., Inc.	The birds of the Beaufort Sea	193
B10-14 M10, OS	M.S. Rodway Canadian Wildlife Service	NESTUCCA oil spill: impact assessment of avian populations and habitat	194
B10-15 M10, OS	M.S. Rodway Canadian Wildlife Service	Distribution and abundance of waterbirds in Barkley Sound and the Long Beach/Tofino/Grice Bay area in spring 1989 following the NESTUCCA oil spill	195
B10-16 M10, OS	M.S. Rodway Canadian Wildlife Service	Foraging activity of migrating Brant at Stubbs Island in April 1989 following the NESTUCCA oil spill	195
B10-17 M10, OS	M.S. Rodway Canadian Wildlife Service	British Columbia seabird colony inventory: Report #4—Scott Islands. Census results from 1982 to 1989 with reference to the NESTUCCA oil spill	196
B10-18 M10, OS	M.S. Rodway Canadian Wildlife Service	Attendance patterns, hatching chronology and breeding population of common murres on Triangle Island, British Columbia, following the NESTUCCA oil spill	197
B12-1 M7,10	D.H. Ward and R.A. Stehn U.S. Fish and Wildlife Service	Response of brant and other geese to aircraft disturbances at Izembek Lagoon, Alaska	201
B12-1 M7,10	D.V. Derkson U.S. Fish and Wildlife Service	Effects of aircraft on the behaviour and ecology of molting brant near Teshekpuk Lake, Alaska	201
B13-1 M15	L. Lockhart Freshwater Institute, DFO	Studies on the condition of fish and hydrocarbon exposure	206
B13-2 B19	D.O. Hodgins, O. Sayao, E. Kinsella, P. Morgan Seaconsult Marine Research Ltd.	Nearshore sediment dynamics - Beaufort Sea	208
B13-3 B19	R.D. Gillie Dobrocky Seatech Ltd.	Beaufort Sea artificial island erosion data	209
B13-4 B19	R. Macdonald and E. Carmack Institute of Ocean Sciences (DFO)	Chemical interactions on the Beaufort Sea Shelf	210
B13-5 OS	N. Vanderkooy and R. Goodman Amoco Petroleum, Esso Resources	Beaufort Sea oil spill modelling and contingency planning	211

INDEX OF PROJECT OVERVIEWS (Page 7)

NUMBER	PRINCIPLE INVESTIGATOR(S) AFFILIATION(S)	TITLE	PAGE
B13-6 M24	Sandra Auchterlonie[1] and Todd Sellers[2] [1]Lutra Associates and [2]The Rawson Academy of Aquatic Science	Survey of fish users in Dene and Metis communities in and near the Mackenzie River watershed	213
B13-7 B19,20 M15, OS	M. Yunker, R.W. Macdonald, B. Fowler, W. Cretney, S. Dallimore, F. McLaughlin Institute of Ocean Sciences (DFO) and Geological Survey of Canada	Geochemistry and fluxes of hydrocarbons to the Beaufort Sea Shelf	214
B13-8 B19,20 OS	M. Yunker[1] and C. Hamilton[2] [1]Institute of Ocean Sciences (DFO) and [2]Seakem Oceanography Ltd.	The distribution of hydrocarbons across the Beaufort Sea Shelf	216
B13-9	[1]C. Gobeil and R.W. Macdonald[2] [1]Institute of Ocean Sciences (DFO) and [2]Institute Maurice Lamontagne (DFO)	Recycling of nutrients and metals from Beaufort Sea Shelf sediments	217
B13-10 B19,20 M15, OS	P. Erickson and B. Fowler Arctic Laboratories Limited	The flux of suspended particulates, petroleum-related hydrocarbons, trace metals and nutrients from the Mackenzie River during the winter season: A pilot study of the East Channel	218
B13-11 B19,20	P. Erickson[1], M. Burnside[1], D. Dickins[2] [1]Seakem Oceanography Ltd. and [2]DF Dickins & Associates	Study of the environmental effects of industry staging activities on the marine environment - Year One	220
B13-12 B20	D.J. Thomas Seakem Oceanography Ltd.	The Tuktoyaktuk Harbour benthic biological monitoring programme	220
B13-13 B20 M15B	R.F. Addison and J.A. Elliot Bedford Institute (DFO)	MFO induction measurement	222
B13-14 B20, OS	R.J. Percy Environment Canada	Condensate effects on commercial species	225
B13-15 B20, OS	C. Hamilton Seakem Oceanography Ltd.	The evaluation and selection of an analytical method to detect a hydrocarbon taint in fish	227
B13-16 B20, OS	J.F. Payne Dept. Fisheries and Oceans	Tainting/contamination potential of weathered oil particulates for commercially-important fish species	228

INDEX OF PROJECT OVERVIEWS (Page 8)

NUMBER	PRINCIPLE INVESTIGATOR(S) AFFILIATION(S)	TITLE	PAGE
B13-17 B19	Steve Solomon[1], Don Forbes[1], Phil Hill[2] [1]Atlantic Geoscience Centre and [2]Hill Geoscience Ltd.	Coastal zone geotechnics (Beaufort Sea)	229
B14-1 B16,17 M14	J.D. Reist Freshwater Institute (DFO)	Broad whitefish stock differentiation	233
B14-2 B15-17 M14,16	J.D. Reist Freshwater Institute (DFO)	Identification of coregonids	234
B14-3 B15-17 M14,16	J.D. Reist Freshwater Institute (DFO)	Hybridization of coregonids	235
B14-4 B15-17 M14,16	J.D. Reist Freshwater Institute (DFO)	External scarring of whitefish, *Coregonus nasus* and *C. clupeaformis* complex, from the western Northwest Territories, Canada	236
B14-5 B15-17 M14,16	J.D. Reist Freshwater Institute (DFO)	Broad whitefish population dynamics	237
B14-6 B15-17	R.H. Hesslein Freshwater Institute (DFO)	The investigation of food chains and fish migration using the stable isotopes of sulfur, carbon, and nitrogen	237
B14-7 B15,16 M16	A. Sekerak and W. Griffith LGL Limited	Overwintering fish habitat in the nearshore Beaufort and Mackenzie Delta	239
B14-8 M13,14	N. Robinson Dept. of Fisheries and Oceans	Fisheries research in the Mackenzie Valley	240
B15-1 M14	W.A. Bond Freshwater Institute (DFO)	Arctic cisco migrations and life history	243
B15-2 M-14	K.T.J. Chang-Kue Freshwater Institute (DFO)	Coastal migrations of Arctic cisco	244
B15-3 B16,17 M14,16	J.D. Reist Freshwater Institute (DFO)	Arctic cisco stock differentiation	245
B20-1	P. Erickson, B. Fowler, D. Thomas Arctic Laboratories Limited	Oil-based drilling muds: Off structure monitoring Beaufort Sea, Minuk I-53 and Kaubvik I-43	259

INDEX OF PROJECT OVERVIEWS (Page 9)

NUMBER	PRINCIPLE INVESTIGATOR(S) AFFILIATION(S)	TITLE	PAGE
B20-2 OS	B. Nakashima and J. Carscadden Bedford Inst. Oceanography (DFO)	Hydrocarbon effects on capelin eggs and larvae	261
B20-3	S. Severin[1] and M.C. Hamilton[2] [1]CBR International and [2]Seakem Oceanography Ltd.	The effect of suspended sediments and dispersants on bacterial floc development and *in situ* oil degradation	262
B20-4	J.F. Payne Dept. of Fisheries and Oceans	Effects of oil-based mud cuttings on fish larvae	264
B20-5	J.F. Payne and J. Kiceniuk Dept. of Fisheries and Oceans	Delineation of toxic zones for fish around oil rig sites: A long-term toxicity study with winter flounder	265
B20-6	J.H. Vandermeulen Dept. of Fisheries and Oceans	Hydrocarbon stress in juvenile fish	266
B20-7 OS	I. Birtwell and C.D. McAllister Dept. of Fisheries and Oceans	The effects of oil exposure on juvenile salmon and their survival to adults: An exposure, tag, release and recapture experiment	266
M1-1 M5,6	P. Kershaw University of Alberta	Successful plant colonizers on disturbances in tundra areas of northwestern Canada	276
M1-2	C.M.M. Smits[1], C.A.S. Smith[2], B.G. Slough[1] [1]Yukon Fish and Wildlife Branch and [2]Agriculture Canada	Physical characteristics, terrain associations and soil properties of Arctic fox dens in Northern Yukon Territory Final Report	277
M1-3	C.M.M. Smits[1], B.G.Slough[1], A. Angerbjorn[2] [1]Yukon Fish and Wildlife Branch and [2]University of Stockholm	Abundance and summer occupancy of Arctic fox dens in Northern Yukon Territory 1984-1988	279
M1-4 M2-11	J.S. Hawkings Canadian Wildlife Service	Vegetation mapping of the Yukon Coastal plain using Landsat thematic mapper imagery	280
M1-5 See text	P.J. Usher[1] and G. Wenzel[2] [1]P.J. Usher Consulting Services and [2]McGill University	Native harvest surveys and statistics: A critique of their construction and use	281
M2-1 M3,7,8	D.A. Walker University of Colorado	Road dust and its environmental impact on Alaskan taiga and tundra	285
M2-2	D. Russell and W. Nixon Canadian Wildlife Service	Summer ecology of the Porcupine Caribou herd in Northern Yukon	287

INDEX OF PROJECT OVERVIEWS (Page 10)

NUMBER	PRINCIPLE INVESTIGATOR(S) AFFILIATION(S)	TITLE	PAGE
M2-3	L.L. Kremsater[1], F.W. Hovey[1], D.E. Russell[2], R.G. White[3], F.L. Bunnell[1], A.M. Martell[4] [1]Faculty of Forestry, University of British Columbia, [2]Canadian Wildlife Service, [3]Institute of Arctic Biology, and [4]Canadian Wildlife Service	Computer simulation models of the Porcupine Caribou herd: ENERGY	289
M2-4	F.W. Hovey[1], L.L. Kremsater[1], R.G. White[3], D.E. Russell[2], F.L. Bunnell[1] [1]Faculty of Forestry, University of British Columbia, [2]Canadian Wildlife Service, Whitehorse, and [3]Institute of Arctic Biology	Computer simulation models of the Porcupine Caribou herd: GROWTH	290
M2-5	F.W. Hovey[1], D.E. Russell[2], F.L. Bunnell[1], R. Farnell[3], K.R. Whitten[4] [1]Faculty of Forestry, University of British Columbia, [2]Canadian Wildlife Service, [3]Yukon Department of Renewable Resources, and [4]Alaska Department of Fish and Game	Computer simulation models of the Porcupine Caribou herd: HARVEST	291
M2-6	G.W. Ellison, A.G. Rappoport, G.M. Reid U.S. Fish and Wildlife Service	Report on the caribou impact analysis workshop, Arctic National Wildlife Refuge, November 19-20, 1985	293
M2-7	S.M. Murphy Alaska Biological Research Inc.	Caribou behaviour and movements in the Kuparuk Oilfield: Implications for energetic and impact analyses	294
M3-1	J.A. Nagy Yukon Fish and Wildlife Branch	Biology and management of grizzly bear on the Yukon North slope	298
M3-2	M. Bromley Dept. Renewable Res. (GNWT)	The status of the barren ground grizzly bear in Canada	299
M3-3	P. Clarkson and I. Liepins Dept. Renewable Res. (GNWT)	Inuvialuit wildlife studies - grizzly bear research	300
M3-4	M. Bromley Dept. Renewable Res. (GNWT)	Safety in bear country - a reference manual	302
M3-5	A. Ott and R. Schideler Alaska Dept. Fish and Game	Use of aversive conditioning to reduce grizzly bear/human conflicts in the North Slope Oilfield	303
M5-1 M6,16	W. Younkin Hardy BBT Limited	Long-term success of seeded species and their influence on native species invasion at abandoned Rig Site A-01, Caribou Hills, N.W.T.	310

INDEX OF PROJECT OVERVIEWS (Page 11)

NUMBER	PRINCIPLE INVESTIGATOR(S) AFFILIATION(S)	TITLE	PAGE
M5-2 M6,16	H. Martens Hardy BBT Limited	Revegetation monitoring of the Interprovincial Pipe Line (NW) Ltd. Norman Wells to Zama Pipeline	311
M6-1	P. Latour and K. Poole Dept. Renewable Res. (GNWT)	Sahtu District marten research	317
M6-2	B.G. Slough, W.R. Archibald, S.S. Beare, R.H. Jessup Dept. Renewable Res. (YTG)	Food habits of marten, *Martes americana*, in the south-central Yukon Territory	318
M6-3	B.G. Slough Dept. Renewable Res. (YTG)	Movements and habitat use by transplanted marten in the Yukon Territory	320
M7-1	D. Wiggins LGL Alaska Research Assoc. Inc.	Use of gravel causeways by nesting common eiders, Beaufort Sea, Alaska, 1990	324
M7-2	S. Johnson LGL Alaska Research Assoc. Inc.	The status of snow geese in the Sagavanirktok River Delta area, Alaska. A progress report: 1980-1990	325
M7-3	K.J. McCormick Canadian Wildlife Service	A survey of trumpeter swans and their habitat in southern Mackenzie District, Northwest Territories: 1986	327
M7-4	Unknown Canadian Wildlife Service	A review of bird sanctuaries in the Northwest Territories (in response to the DIAND Northern Mineral Policy)	328
M7-5 M10	R.R. Ritchie Alaska Biological Research Inc.	Tundra swan and brant surveys on the Arctic coastal plain, Colville River to Staines River	329
M8-1	C. Shank Dept. Renewable Res. (GNWT)	Pesticide analysis of ptarmigan near Tuktoyaktuk and at the mouth of the Anderson River	335
M8-2	C. Shank Dept. Renewable Res. (GNWT)	1990 Summary of Northwest Territories Raptor Project	336
M8-3	C. Shank Dept. Renewable Res. (GNWT)	Numerical changes in two breeding populations of tundra peregrine falcons in the Central Canadian Arctic	337
M8-4	C. Shank Dept. Renewable Res. (GNWT)	1990 North American peregrine falcon survey, Mackenzie River Valley, Northwest Territories	338
M8-5	Unknown Canadian Wildlife Service	Gyrfalcons in the Richardson Mountains	339
M8-6	D. Mossop Dept. Renewable Res. (GNWT)	Yukon gyrfalcon project: 1987 and 1988	340
M8-7	D. Mossop Dept. Renewable Res. (GNWT)	The Yukon peregrine falcon recovery project 1987	341

INDEX OF PROJECT OVERVIEWS (Page 12)

NUMBER	PRINCIPLE INVESTIGATOR(S) AFFILIATION(S)	TITLE	PAGE
M8-8	D. Talarico Dept. Renewable Res. (GNWT)	Herschel Island avifauna monitoring project	342
M9-1 M22	D. Mossop Dept. Renewable Res. (YTG)	Bird watching enterprise: pilot trip on Yukon North Slope	346
M11-1 M16	K.L. MacInnes Indian and North. Affairs Canada	Permafrost and terrain research and monitoring: Norman Wells Pipeline Volume I: Environmental and engineering considerations; Volume II: Research and monitoring results, 1983-1988	354
M11-2	R.E. Hecky Freshwater Institute (DFO)	Limnological research on lakes and channels in the Mackenzie Delta and lakes on the Tuktoyaktuk Peninsula, N.W.T.	355
M14-1 M16	J.D. Reist Freshwater Institute (DFO)	Charr stock differentiation	362
M16-1	K.T.J. Chang-Kue Freshwater Institute (DFO)	Evaluation of logjam clearing operations at Kenaksek Creek	372
M22-1 M24	Unknown Dept. of Fisheries and Oceans and Fish. Joint Management Com.	Harvest Study - South of Inuvialuit Settlement Region	386
M22-2 M23,24	Sparling and Sparling Sparling Consultants	Data report based on information collected in 1981 during a survey of the domestic fishery in the Mackenzie Delta area, Northwest Territories	387
M22-3 M23,24	R. Hall Dept. Renewable Res. (GNWT)	Individual trapping - record summary	388
M25-1	D. Grant-Francis Dept. Renewable Res. (GNWT)	Summary of 1987/88, 1988/89, 1989/90 resident hunter harvest survey	397
OS-1	J.M. Neff Batelle Ocean Sciences	Water quality in Prince William Sound	399
OS-2	Beaufort Sea Steering Committee, Task Group 2 - Remediation and Restoration (Various Affil.)	Wildlife and wildlife habitat restoration and compensation in the event of an oil spill in the Beaufort Sea	401
OS-3	Beaufort Sea Steering Committee, Task Group 4 - Research and Science (Various Affil.)	Scientific response planning, information database requirements and environmental assessment methodology for an oil spill in the Beaufort Sea	403
OS-4	Anonymous Exxon Corporation	Valdez Oil Spill Technology, 1989 Operations	406

INDEX OF PROJECT OVERVIEWS (Page 13)

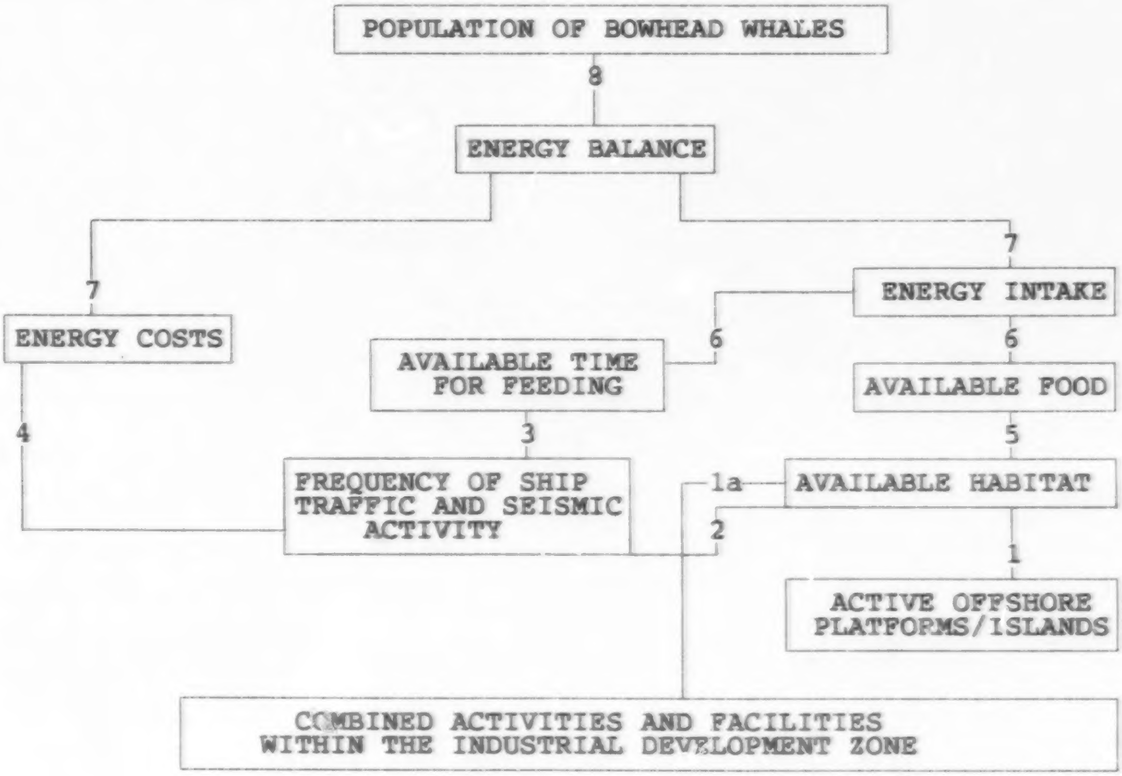
NUMBER	PRINCIPLE INVESTIGATOR(S) AFFILIATION(S)	TITLE	PAGE
OS-5	R.W. Macdonald and E. Carmack Institute of Ocean Sciences (DFO)	The role of large-scale under ice topography in seperating estuary and ocean on an Arctic Shelf	407
OS-6	R.W. Macdonald and E. Carmack Institute of Ocean Sciences (DFO)	Primary Productivity on the Beaufort Sea Shelf	408
OS-7	M. Fingas, I. Bier, M. Bobra, S. Callaghan Environment Canada	Studies on the physical and chemical behaviour of oil and dispersant mixtures	409
OS-8	M. Kennicutt II, S. Sweet, W. Fraser, M. Culver, W. Stockton Texas A&M Univ. and Univ. of California	The fate of diesel fuel spilled by the BAHIA PARIASO in Arthur Harbour, Antarctica	411
OS-9	M. Bobra Consultchem Ltd.	Water-in-oil emulsification: a physicochemical study	412
OS-10	W. Duval, S. Hopkinson, R. Olmsted, R. Kashino ESL Environmental Sciences Ltd.	The NESTUCCA oil spill: preliminary evaluation of impacts on the west coast of Vancouver Island	413

5.1 RESEARCH RELEVANT TO BEMP HYPOTHESES

The following lists all of the BEMP impact hypotheses and their linkages as they were presented in the 1986-1987 BEMP report (INAC and Environment Canada 1988). It also includes a discussion of the major findings of research and its relevance to BREAM. Each of the studies is described following the first hypothesis to which it is relevant. In cases where research is relevant to more than one hypothesis, cross referencing has been used both in the first description of the project and in "Other Relevant Projects" tables included with each hypothesis.

BEMP HYPOTHESIS NO. 1

SHIP TRAFFIC, SEISMIC EXPLORATION AND ACTIVE OFFSHORE STRUCTURES WILL CAUSE A REDUCTION IN THE WESTERN ARCTIC POPULATION OF BOWHEAD WHALES


POPULATION OF BOWHEAD WHALES
8
ENERGY BALANCE
7
7
ENERGY INTAKE
ENERGY COSTS
6
6
AVAILABLE TIME FOR FEEDING
AVAILABLE FOOD
4
3
5
FREQUENCY OF SHIP TRAFFIC AND SEISMIC ACTIVITY
1a
AVAILABLE HABITAT
2
1
ACTIVE OFFSHORE PLATFORMS/ISLANDS
COMBINED ACTIVITIES AND FACILITIES WITHIN THE INDUSTRIAL DEVELOPMENT ZONE

LINKAGES

1a. The cumulative effect of all offshore industrial activities will be to create a large-scale zone of bowhead whale exclusion encompassing the entire industrial zone.*

1. Each active offshore island or platform will exclude bowheads from a zone around the island/platform.

2. Ship traffic will exclude bowheads from a zone around the ship track.

3. Each passage of a ship will reduce the feeding time available to bowheads.

4. Each passage of a ship will increase the energy expenditure of whales due to avoidance behaviour.

5. The available aquatic habitat determines the level of available food.

6. The amount of available food and the time available for feeding determine the energy intake.

7. Energy intake and expenditures determine the energy balance of a bowhead whale.

8. The energy balance of a bowhead whale determines its survival and its ability to reproduce.

* This hypothesis link was added to more clearly represent the emphasis on the cumulative impact of hydrocarbon development on bowhead whales.

Beaufort Sea Oceanography

BREAM PROJECT OVERVIEW NO. B1-1

PRINCIPAL INVESTIGATOR:	R. W. Macdonald
AFFILIATION:	Department of Fisheries and Oceans, Institute of Ocean Sciences
FUNDING SOURCE:	NOGAP and DFO
EXPECTED COMPLETION DATE:	1992
RELEVANT HYPOTHESIS NO.:	BEMP 1, 3, 4, 6, 13, 19 and 20

BRIEF PROJECT DESCRIPTION

The objective of this investigation is to examine natural hydrocarbon distributions and levels of primary productivity on the Mackenzie shelf and within the estuary. Within the southeastern Beaufort Sea, the Mackenzie River and Delta represent the main sources of natural hydrocarbons, with suspended particulates being the dominant carriers. The study design is based on the premise that the optimal way to predict possible impacts of industrial discharges of hydrocarbons associated with offshore oil and gas activities is to (1) study and model the processes governing natural distributions of the same compounds, and (2) measure transport mechanisms that could concentrate or dilute contaminants within the shelf/estuary system, or move them off the shelf.

This project has been conducted in two parts. Results of the first phase (1986 to 1990) have been published in scientific journals. To date, these results reflect considerable progress in understanding the role of the Mackenzie River, and the scales, boundaries and water masses that are important in the transport and distribution of hydrocarbons in the Beaufort Sea. The data sets are currently being used to study: (1) the sources, magnitude and sinks of hydrocarbons; (2) nearshore transport in response to autumn storms; and (3) the seasonality of primary production as recorded in sequential sediment traps and time-series transect sampling.

The second phase of the project (1990 to 1992) focuses on current deficiencies in information regarding: (1) the interannual variability of primary production on the Mackenzie shelf and methods for predicting this variability; (2) the nearshore transport of contaminants and biota, particularly under the ice; and (3) the seasonality of primary production and cross-shelf transport events in the nearshore zone and flaw lead system. Results of the first phase of the project and new field studies conducted during the second phase will provide information to further study these issues.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

Information on primary production in the Beaufort Sea and its seasonal and interannual variability is directly relevant to BEMP Hypothesis No. 6, which deals with the effects of ice thickness and location on the level of primary productivity and, ultimately, on food sources of ringed seal and polar bear populations in Amundsen Gulf. It is also indirectly relevant to Hypotheses Nos. 1, 3 and 4. In addition, baseline data on the sources and distribution of natural hydrocarbons in the southeastern Beaufort Sea will allow a more accurate assessment of the impacts of hydrocarbons from anthropogenic sources, which is dealt with in Hypotheses Nos. 13, 19 and 20.

Beaufort Sea Zooplankton Distributions, 1987

BREAM PROJECT OVERVIEW NO. B1-2

PRINCIPAL INVESTIGATORS:	D. Fissel[1] and M. Bradstreet[2]
AFFILIATION:	[1]Arctic Sciences Ltd. and [2]LGL Limited
FUNDING SOURCE:	DSS and INAC
COMPLETION DATE:	1989
RELEVANT HYPOTHESIS NO.:	BEMP 1

BRIEF PROJECT DESCRIPTION

This primary objective of this project was to gain a better understanding of food availability for bowhead whales in the Mackenzie Shelf region. It was designed to supplement the results of research conducted in 1985 and 1986 (Environmental Studies No. 50, Indian and Northern Affairs Canada, Ottawa), as well as to test an acoustic system to measure zooplankton distributions along the ship transects. The acoustic system, involving three distinct acoustic frequencies, was not successful in providing quantitative measurements of zooplankton abundance. A more sophisticated and considerably more expensive system would be required for this purpose. However, data obtained by conventional net sampling, along with oceanographic data collected concurrently with sampling, have provided additional information on food availability for bowhead whales.

During the 1987 field program, the mean and maximum concentrations of zooplankton were much lower than those measured in 1985 and 1986 in the same general area. The dominant types of zooplankton were large mysids, euphausiids and decapods, in contrast to the large numbers of copepods present in the previous years. Unusual physical oceanographic features such as early and extensive clearing of sea ice, and high ocean temperatures and salinities may have caused the usually-dominant copepods to complete their usage of near-surface shelf waters earlier than normal.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This project provides information relevant to BEMP Hypothesis No. 1, particularly Links 5 and 6. These linkages relate to the apparent role of the southeast Beaufort Sea as an important feeding ground for bowheads during the months of August and September. Results of this study add to the "weight of evidence" regarding the validity of the two hypotheses that have been proposed to account for the interannual variability in distribution patterns of bowheads in the southeastern Beaufort Sea during 1980-86. These are that (1) whales may be avoiding the industrial zone as a behavioral response to industrial activity, and (2) they are responding to fluctuations in the distribution and abundance of food.

The Distribution of Nutrients in the Southeastern Beaufort Sea: Implications for Water Circulation and Primary Production

BREAM PROJECT OVERVIEW NO. B1-3

PRINCIPAL INVESTIGATOR:	R.W. MacDonald
AFFILIATION:	Department of Fisheries and Oceans, Institute of Ocean Sciences
FUNDING SOURCE:	Beaufort Sea Project, Polar Continental Shelf Project, NOGAP
COMPLETION DATE:	1987
RELEVANT HYPOTHESIS NO.:	BEMP 1, 3, 6, 16 and 20 MEMP 11 and 16

BRIEF PROJECT DESCRIPTION

Oceanographic data were collected at 25 stations in August 1974 and 30 in August 1975 in order to characterize the nutrient (reactive phosphate, nitrate+nitrite, silicate), temperature, salinity and oxygen regimes along the shelf and slope of the southeastern Beaufort Sea. Chemical and physical conditions were different between the two years and these differences were attributed to heavy ice conditions near shore in 1974. 'New' production, as roughly estimated by calculations from an assumed C:N ratio of 6.6:1, was 16 g C m^{-2} yr^{-1} and 23 g C m^{-2} yr^{-1} for 1974 and 1975, respectively, which is fairly typical of arctic regions in general. The lower value in 1974 was attributed to heavy ice and turbid water. Upwelling was observed in both years at the eastern side of the Mackenzie Canyon.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

Physical and chemical oceanographic conditions, particularly those associated with upwelling, are major controlling influences on the rates of primary production by phytoplankton. In turn, the amount of secondary production by zooplankton is highly dependent on their food base (i.e., phytoplankton). Upwelling influences zooplankton abundance and distribution both in terms of production and by providing a concentrating mechanism. This study is therefore related to an interrelated hypothesis that 'bowhead distribution is controlled by oceanographic factors which influence the availability of food.' It is also indirectly related to other hypotheses that deal with species such as Arctic cisco, broad whitefish, or groups such as fish, waterfowl, and marine mammals, all of which are dependent on zooplankton, to varying degrees, at some point in their life cycle.

Production studies in the Mackenzie River-Beaufort Sea Estuary

BREAM PROJECT OVERVIEW NO. B1-4

PRINCIPAL INVESTIGATOR:	T. R. Parsons
AFFILIATION:	University of British Columbia
FUNDING SOURCE:	NOGAP
COMPLETION DATE:	1988
RELEVANT HYPOTHESIS NO.:	BEMP 1, 3, 6, 16 and 20 MEMP 11 and 16

BRIEF PROJECT DESCRIPTION

Objectives of the study were to determine if the Mackenzie River estuary displays typical estuarine distributions in primary production and dissolved organic carbon (DOC), and to compare quantitatively the heterotrophic (bacterial) nearshore food chain with the autotrophic, phytoplankton-based, offshore food chain.

A series of 12 oceanographic stations were sampled in Kugmallit Bay and further offshore in the southeastern Beaufort Sea for primary production, chlorophyll a and phaeophytin, bacterial counts, glucose and thymidine uptake, light attenuation, temperature, salinity, DOC, zooplankton, and phytoplankton (including Protozoa). Sampling was conducted from 22 to 27 July and 27 to 30 August, 1986.

Production, chlorophyll a and salinity were all highest at the station farthest offshore. DOC was highest near shore and then decreased with increasing salinity until salinity was >20 ppt when DOC increased again. The nearshore DOC peaks were due to riverine influences and the offshore peak was likely due to the high production offshore. Bacterial numbers and activity were highest nearshore, although activity was also relatively high in association with the high values of DOC offshore. The offshore phytoplankton community was dominated by the diatoms *Chaetoceros* spp., whereas dinoflagellates dominated in the estuary. Marine zooplankton communities were dominated by copepods, hydromedusae and ctenophores, and brackish waters were dominated by amphipods. Mysids were present in both estuarine and offshore waters.

The observed patterns were typical of estuaries in general. Nearshore heterotrophic production was estimated at 4.8 mg C m^{-3} day^{-1} versus 220 mg C m^{-3} day^{-1} for the autotrophic offshore production by phytoplankton.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

Carbon forms the basis of all aquatic food chains. The study documents the levels of carbon production by bacteria and phytoplankton both in the estuary and farther offshore and thus is relevant to all hypotheses dealing with the distribution, abundance and energetics of fish, waterfowl and marine mammals.

Ecological Factors Governing the Distribution and Abundance of the Copepod, *Limnocalanus macrurus*, in the Beaufort Sea

BREAM PROJECT OVERVIEW NO. B1-5

PRINCIPAL INVESTIGATOR:	A.D. Sekerak
AFFILIATION:	LGL Limited
FUNDING SOURCE:	NOGAP
EXPECTED COMPLETION DATE:	1991
RELEVANT HYPOTHESIS NO.:	BEMP 1, 3, 6, 16 and 20 MEMP 11 and 16

BRIEF PROJECT DESCRIPTION

The objectives of this study were to investigate environmental factors that may control the distribution and abundance of the estuarine copepod *Limnocalanus macrurus*. A number of previous authors have postulated that dense patches of this species are important food resources for bowhead whales in nearshore waters in the vicinity of the Mackenzie River Delta in late summer and fall. A total of 389 zooplankton samples (horizontal bongo samples) was collected from Kaktovik, Alaska to the Tuktoyaktuk Peninsula during 1985, 1986, and 1987 by LGL Limited, Arctic Sciences Ltd. and the Department of Fisheries and Oceans.

Limnocalanus macrurus accounted for 48% of total numbers of copepods, with mean densities of about 1000 m^{-3} in patches. Densities were as high as 2000 m^{-3} in certain areas and times. Dense patches occurred along the Tuktoyaktuk Peninsula, off Richards Island and along the Alaskan coast, but they were most common along the Yukon coast. Mean densities by area and year are shown in the following table.

ABUNDANCE (NO.M^{-3}) OF *LIMNOCALANUS MACRURUS* IN FIVE AREAS OF THE BEAUFORT SEA, 1985, 1986 AND 1987.

	1985			1986			1987		
AREA	MEAN	S.D.	N	MEAN	S.D.	N	MEAN	S.D.	N
Tuk	93	194	20	43	90	18	1	2	14
Tuk Pen East Delta	537	590	34	416	1423	53	7	38	72
Yukon Coast	893	1382	64	954	1259	24	293	425	8
East Alaska	78	142	25	306	724	14	0	0	0
Offshore	278	683	18	1	2	8	0	0	0
All	523	998	161	427	1173	117	28	138	104

Limnocalanus macrurus appeared to be concentrated by fronts, and maximum densities were predicted by regression analyses to occur about 4 km from the front. Concentrations were also related to water mass type and were greatest when two or more water masses were present with relatively fresh Mackenzie River water at the surface. It was concluded that winds are probably the single most important concentrating mechanism in late summer and fall.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study is of most relevance to Hypothesis No. 1, particularly the interrelated hypothesis concerning the importance of oceanographic conditions that determine the distribution of zooplankton, which in turns influences the distribution of bowheads. The study has shown that *Limnocalanus macrurus*, an apparently important food resource for bowheads in the area, does display marked differences in abundance due to such factors as annual variation, geographic location, presence of fronts, wind conditions, etc.

The study is also of some relevance to other hypotheses concerning fish, bird and mammal distribution because at some time or life stage, many species are dependent upon zooplankton.

Zooplankton and Bowhead Whale Feeding in the Canadian Beaufort Sea, 1986

BREAM PROJECT OVERVIEW NO. B1-6

PRINCIPAL INVESTIGATOR:	M.S.W. Bradstreet
AFFILIATION:	LGL Limited
FUNDING SOURCE:	NOGAP
COMPLETION DATE:	1987
RELEVANT HYPOTHESIS NO.:	BEMP 1, 3, 6, 16 and 20 MEMP 11 and 16

BRIEF PROJECT DESCRIPTION

The primary objectives of the study were to document food resources available to bowhead whales and the physical mechanisms influencing the distribution of these resources, and to compare feeding areas with non-feeding areas. The study was directed at those natural mechanisms that determine bowhead distributions rather than industrial activity that may alter their behaviour. Results are based upon data from 176 CTD stations and 202 zooplankton samples (oblique and horizontal bongo samples) collected at 43 stations in the southern Beaufort Sea during August-September 1986.

The mean total biomass of zooplankton (oblique tows) in the upper 50 m was 172 mg m^{-3}, with copepods dominating (65% of biomass). Calanoid copepods were the dominant group, particularly *Calanus hyperboreus*, *Calanus glacialis*, and *Limnocalanus macrurus*. There were significant differences geographically in both total zooplankton and copepod biomass for samples that were collected from water depths equal to or > 40 m. Biomass was greater off Richards Island and off the Tuktoyaktuk Peninsula than off the Yukon coast. Mysids, euphausiids, and YOY cod appeared to be more abundant in shallow water than farther offshore.

Zooplankton were clearly concentrated into discrete layers in many areas, and, overall, the mean biomass within layers was 2.6 times higher than outside the layers. Arctic Water at the surface contained a biomass 8.0 times higher than other areas. For below surface horizontal tows, Arctic Water was characterized by high biomass, Intense Plume Water by low biomass, and Diffuse Plume Water by an intermediate biomass. Multiple regression analyses revealed that biomass in 1986 was highest in water with no influence from the Mackenzie River and lowest where riverine influence was greatest. Sampling in frontal areas was not extensive but at the one that was sampled, biomass was higher on the clear cold side (where whales were feeding) than on the warm turbid side.

Fifteen stations were sampled in the general vicinity of feeding whales and mean biomasses, depending upon the type of tow ranged from 2-6 times higher than in those areas without whales. The highest biomasses obtained were at a shallow station off the Yukon coast in the midst of 12 feeding bowheads. Maximum biomass was 1543 mg m^{-3} at a depth of 3 m. *Limnocalanus macrurus* was the dominant species at that station.

Copepods and euphausiids had the highest caloric values. Caloric content of zooplankton was higher in 1985 than in 1986, when chlorophyll a values and degree of upwelling were also higher. *Limnocalanus macrurus* had the highest lipid values. Previous theoretical calculations have led to a hypothesis that whales must feed in areas where zooplankton are concentrated in order to meet their energy requirements. This study has shown that the areas where whales feed show evidence of concentrated zooplankton biomass.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study is of most relevance to Hypothesis No. 1, particularly the interrelated hypothesis concerning the importance of oceanographic conditions that determine the distribution of zooplankton, which in turns influences the distribution of bowheads. The most important finding of the study was that bowheads feed in areas of concentrated zooplankton, particularly copepods (specifically *L. macrurus* in the present case), a group (species) high in caloric value and lipid content.

The study is also of some relevance to other hypotheses concerning fish, marine birds, and marine mammals distribution, abundance, and energetics.

Zooplankton of a Bowhead Whale Feeding Area off the Yukon coast in August 1985

BREAM PROJECT OVERVIEW NO. B1-7

PRINCIPAL INVESTIGATOR:	M.S.W. Bradstreet
AFFILIATION:	LGL Limited
FUNDING SOURCE:	NOGAP
COMPLETION DATE:	1986
RELEVANT HYPOTHESIS NO.:	BEMP 1, 3, 6, 16 and 20 MEMP 11 and 16

BRIEF PROJECT DESCRIPTION

The broad objective of this study was to conduct field investigations on oceanographic conditions and the presence of planktonic food in order to better understand the significance of the study area in the bowhead whale's annual energy budget. Within this overall objective, four tasks were to: (1) characterize the physical oceanography; (2) document zooplankton biomasses; (3) assess food value of available zooplankton; and (4) integrate the results with those available from a similar study conducted in Alaska.

T-S profiles were obtained at 29 stations and zooplankton at 25 stations, including a station 'with whales' and a control station. Both oblique and horizontal bongo tows were undertaken. The zooplankton was dominated by *Limnocalanus macrurus*, followed by *Calanus hyperboreus* and *Calanus glacialis*. Surface tows contained highest biomasses in Arctic Water. Zooplankton concentrations were greatest in horizontal layers. The hydrographic regime occurring off the Yukon coast in late summer is conducive to the formation of zooplankton concentrations when there are easterly prevailing winds.

The theoretical feeding requirements for bowhead whales are zooplankton densities of about 1.0 g m^{-3}. This value was exceeded in nine of 41 horizontal tows, and echosounding records suggested that about 59% of the study area contained zooplankton densities exceeding 1.0 g m^{-3} at some depth in the water column. Zooplankton density was 2.3 g m^{-3} near feeding whales, with *Limnocalanus macrurus* being the dominant species in this area.

In 1985, zooplankton biomasses were lower and bowhead whales were scarcer than normal off Alaska. It was apparent that locations with high biomass of zooplankton vary from year to year, as do the dominant species.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study is of most relevance to Hypothesis No. 1, particularly the interrelated hypothesis concerning the importance of oceanographic conditions that determine the distribution of zooplankton, which in turns influences the distribution of bowheads. The most important finding of the study was that bowheads feed in areas of concentrated zooplankton, particularly copepods (specifically *L. macrurus* in the present case), a group (species) high in caloric value and lipid content.

The study is also of some relevance to other hypotheses concerning fish, marine birds, and marine mammals distribution, abundance, and energetics.

Importance of the Eastern Alaska Beaufort Sea to Feeding Bowhead Whales, 1985

BREAM PROJECT OVERVIEW NO. B1-8

PRINCIPAL INVESTIGATOR:	W.J. Richardson
AFFILIATION:	LGL Limited
FUNDING SOURCE:	U.S. Minerals Management Service
COMPLETION DATE:	1986
RELEVANT HYPOTHESIS NO.:	BEMP 1

BRIEF PROJECT DESCRIPTION

This report describes the results of the first year of two years of studies by various researchers on water mass distributions, zooplankton and hydroacoustics, bowhead distribution, numbers and activities, and energetics. The following is quoted directly from the abstract. The second year of study, which incorporates information from this report, is summarized in more detail in a subsequent project overview.

The general purpose of the two-year project is to quantify what proportion of the energy requirements of the Western Arctic bowhead whale stock is provided by food resources located in the Eastern Alaskan Beaufort Sea (Alaska/Canada border to 144° W). Specific objectives are to:

1. *determine the concentration and distribution of the planktonic food of bowhead whales in the Eastern Alaskan Beaufort Sea and correlate with known oceanographic features;*
2. *estimate the number of bowhead whales utilizing the Eastern Alaskan Beaufort Sea as a feeding area during the summer and fall; observe and document their feeding activities, behaviour and residence times; and*
3. *estimate the degree of utilization of available food resources to the Eastern Alaskan Beaufort Sea by the Western Arctic bowhead whale stock.*

This report describes the results of field work completed in September and early October 1985, the first of two planned field seasons.

Water masses in the study area were studied by boat-based sampling and by airborne and satellite remote sensing. After a period of prolonged easterly winds, water masses included (1) a narrow nearshore band of relatively warm water, (2) an area of cold, high salinity water over the inner shelf, with strong evidence of upwelling, and (3) an area of warmer, fresher, more turbid water (of Mackenzie Bay origin) near and beyond the shelf break. Fronts and eddies were detected in the study area. After a period of strong west winds, much ice had blown into the study area and the 'Mackenzie plume' was no longer present.

Zooplankton composition, biomass, distribution, patchiness, and energy content were documented by boat-based sampling along three SSW-NNE transects. Most net sampling was done with oblique bongo tows and by horizontal tows in plankton layers identified by echosounding. Quantitative echosounding techniques, calibrated by the bongo sampling, were also used. Maximum zooplankton biomass generally occurred in one or more 5-10 m layers in the 8-40 m depth zone. Biomass was usually very low in near-surface waters, and it decreased with increasing distance from shore. Copepods dominated the biomass. During the late summer of 1985, dense concentrations of zooplankton seemed to be less common in this study area than off the Yukon coast; many bowhead whales fed in the latter area.

The distribution, numbers and activities of bowhead whales were determined by aerial surveys, and behavioral observations were made from the aircraft. Photogrammetric methods were used to document whale sizes and the recurrence of identifiable individuals in feeding areas. Unusually few bowheads fed in the study area in late summer and autumn of 1985. The one major feeding area in the official study area was 30-40 km north and northeast of Kaktovik; relatively low numbers of bowheads fed there, mainly well below the surface, for at most a few days in late September. In contrast to the low abundance and apparently short residence times of bowheads within the study area, numerous bowheads fed along the Yukon shore about 30 km east of the official study area in late August and September; some recognizable individuals were there for at least 16 days.

The Western Arctic population of bowheads acquired a very low percentage of its annual food and energy needs within the study area in 1985. In many parts of the study area, zooplankton biomass appeared to be too low for efficient feeding. Bowheads probably consumed several times less food in the study area in 1985 than during most years. It is not yet known whether zooplankton availability is higher in years when the study area is more heavily utilized by feeding bowheads.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

The results of the study have shown that both zooplankton biomass and numbers of feeding bowheads were low in the eastern Alaska Beaufort Sea during 1985. The Yukon coast was a more important feeding area during that year. The study is of most relevance to Hypothesis No. 1, and results are suggestive of bowhead feeding strategies that involve seeking out areas and times of zooplankton concentrations in order to efficiently meet their food requirements. If bowheads actively seek areas where zooplankton are concentrated, then their distributions in the area are subject to many influences from natural sources in addition to any modifications of behaviour due to industrial activity.

Importance of the Eastern Alaskan Beaufort Sea to Feeding Bowhead Whales, 1985-86

BREAM PROJECT OVERVIEW NO. B1-9

PRINCIPAL INVESTIGATOR:	W.J. Richardson
AFFILIATION:	LGL Limited
FUNDING SOURCE:	U.S. Minerals Management Service
COMPLETION DATE:	1987
RELEVANT HYPOTHESIS NO.:	BEMP 1

BRIEF PROJECT DESCRIPTION

This report details the results of two years of studies by various researchers on the food resources for the western Arctic bowhead whale stock in the eastern Alaskan Beaufort sea. Specific objectives were to:

1. determine the concentration and distribution of the planktonic food of bowhead whales in the Eastern Alaskan Beaufort Sea and correlate these with known oceanographic features;

2. estimate the number of bowhead whales utilizing the Eastern Alaskan Beaufort Sea as a feeding area during the summer and fall; observe and document their feeding activities, behaviour and residence times; and

3. estimate the degree of utilization of available food resources to the Eastern Alaskan Beaufort Sea by the Western Arctic bowhead whale stock.

The report is based on field surveys conducted in September and early October of 1985 and 1986. Oceanographic conditions, as measured by CTD and remote sensing techniques, were variable between years. The influence of the Mackenzie plume, warm, fresh, turbid water, was greatest in early September 1985. In September 1985, the lower water layer (depth >32m) was exclusively cold, saline Arctic Surface Water whereas in September 1986, a prominent warm, subsurface core of Bering Sea Water was present over the outer continental shelf and slope. In both years, Mackenzie Bay water was present in the upper layers offshore and there was a nearshore band of estuarine water.

There was strong evidence in the CTD and nutrient data of coastal upwelling due to consistent easterly winds in the inner shelf zone during the 1985 sampling period but not in 1986. Both large-scale and small-scale oceanographic fronts are common in the study area as evidenced by airborne and satellite remote sensing and aircraft and boat sampling. One relatively consistent front occurs along the inshore side of the warm, less saline Mackenzie Bay water near the shelf break. Another front separates turbid nearshore waters from cooler and clearer inner shelf waters.

Like oceanographic conditions, zooplankton communities also varied between years. The copepods *Calanus hyperboreus* and *Calanus glacialis* dominated in September 1985, whereas *Limnocalanus macrurus* dominated in 1986. In both years, average zooplankton biomass was highest nearshore (within the 50 m contour) and lower on the outer shelf (outside the 50 m contour). Average biomass (200 mg m^{-3}) was similar in both years and comparable to the Canadian Beaufort in the same years. Hydroacoustic surveys confirmed the patchy nature of zooplankton populations. Feeding bowheads were present in the southeast portion of the study area in early September 1986 but were absent in September 1985. Zooplankton biomass was generally higher at whale feeding locations.

Bowhead whale distribution and activities were observed during aerial surveys in both years, and five bowheads were radio-tagged in 1986. The late summer and autumn of 1985 was atypical in that few bowheads fed in the area, whereas 1986 was more typical with about 50 subadults utilizing the southeast corner of the study area. In both years, numerous bowheads fed along the Yukon coast, just east of the study area. After active migration began in mid September, adult and large subadult whales fed in the middle-shelf portion of the study area in both years.

The Western Arctic population of bowheads acquired a low percentage of annual energy needs within the study area (from <1% in 1985 to about 1.4% in 1986). Many parts of the study area support zooplankton populations that are too sparse for efficient feeding. It appears, therefore, that a significant part of their food must be obtained in the Canadian portion of the Beaufort Sea.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

The study is of most relevance to Hypothesis No. 1, particularly the interrelated hypothesis concerning physical and biological oceanographic influences on distributions of bowheads. The study has shown that nearshore zooplankton concentrations are variable from year to year as are physical oceanographic conditions; bowheads appear to change their feeding distributions accordingly. The Canadian portion of the Beaufort Sea appears to supply more of the bowheads' energy requirements than does the Alaskan Beaufort.

This study, as with the other zooplankton studies, is of relevance to species other than bowheads that are dependent upon zooplankton-based food chains.

Zooplankton Distributions in the Southeastern Beaufort Sea, Summer 1987

BREAM PROJECT OVERVIEW NO. B1-10

PRINCIPAL INVESTIGATORS:	Various
AFFILIATION:	Arctic Sciences Ltd. and LGL Limited
FUNDING SOURCE:	Indian and Northern Affairs Canada, Supply and Services Unsolicited Proposal Fund, and Arctic Sciences Ltd.
COMPLETION DATE:	1989
RELEVANT HYPOTHESIS NO.:	BEMP 1, 3, 6, 16 and 20 MEMP 11 and 16

BRIEF PROJECT DESCRIPTION

The objectives of this study were to: (1) continue previous zooplankton investigations in the southeastern Beaufort Sea; (2) document physical oceanographic features that may control zooplankton distributions; and (3) test newly-developed hydroacoustic equipment (triple frequency) for broad-scale zooplankton surveys.

A total of 79 zooplankton samples (horizontal bongos) were collected over the continental shelf in the Canadian sector of the southeastern Beaufort Sea from 27 August to 8 September 1987. Associated temperature, salinity and turbidity profiles were also obtained. Zooplankton biomass was markedly reduced in 1987 compared to the previous two years. The species composition was also considerably different in 1987, with copepods comprising only 4% of the biomass in 1987 compared to 73% in 1985 and 32% in 1986. In 1987, mysids, euphausiids and decapods dominated (48% of biomass) the plankton, whereas they only composed 7% of the plankton in 1986. Variations within the 1987 data set in terms of biomass and species composition were also unusually large. It is postulated that the record-high ocean temperatures and near record-high salinities due to the rapid clearing of shelf ice by early July were responsible for the unusual difference compared to previous years.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study is of most relevance to BEMP Hypothesis No. 1, particularly the interrelated hypothesis concerning the importance of oceanographic conditions that determine the distribution of zooplankton, which in turns influences the distribution of bowheads. Zooplankton biomasses during the summer of 1987 were more variable by location and species composition than in previous years. This may have been due to the unusually high temperatures and salinities in 1987.

The study is also of some relevance to other hypotheses concerning fish, bird and mammal distribution because at some life stage, or at some point in their food chain, many species are dependent upon zooplankton.

Distribution and Life History of *Limnocalanus macrurus*, an Estuarine Copepod, in the Beaufort Sea (Draft)

BREAM PROJECT OVERVIEW NO. B1-11

PRINCIPAL INVESTIGATOR:	A.D. Sekerak
AFFILIATION:	LGL Limited
FUNDING SOURCE:	NOGAP, Supply and Services Unsolicited Proposal Fund, Inuvialuit Fisheries Joint Management Committee, and Science Institute of the NWT
EXPECTED COMPLETION DATE:	1991
RELEVANT HYPOTHESIS NO.:	BEMP 1, 3, 6, 16 and 20 MEMP 11 and 16

BRIEF PROJECT DESCRIPTION

The objectives of this study were to document the distribution and life history of *Limnocalanus macrurus* in the southern Beaufort Sea. It was based on zooplankton samples collected by LGL and the Department of Fisheries and Oceans during the open water season in 1985 (n=26), 1986 (n=47), 1987 (n=33), and 1988 (n=309). A few samples were taken through the ice in March (n=5) and May (n=6).

Although the authors found no direct evidence of breeding in the Beaufort Sea, the distribution of naupliar and copepodite stages indicated that breeding likely occurs there between early October and April. The various generations are well separated except for a few long-lived adults that survive throughout the winter until the following spring or summer.

The largest concentrations have been consistently found in Mackenzie Bay-Kugmallit region. Only small numbers are found beyond the 50 m contour and along the northeastern Tuktoyaktuk Peninsula. Zooplankton are known to become concentrated along fronts between the Mackenzie Plume and Arctic Ocean water, and have recently been found to be an important food source for bowhead whales.

The brackish water area maintained by the Mackenzie River during winter is an important breeding area for *L. macrurus* and, as such, may be critical to the viability of the large populations presently found in the area.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

The study is relevant to a number of hypotheses concerning the distribution and abundance of marine and anadromous fish, marine birds, waterfowl and marine mammals, which rely directly or indirectly on *L. macrurus* as a food source. The research is most relevant to BEMP Hypothesis No. 1.

Results of the study suggest that the Mackenzie estuary is an important breeding/nursery area for *L. macrurus* in winter. As such, any changes in the physical or chemical characteristics of the winter inflow may affect this species at the population level. Any large changes in the population size of this species have the potential to cause an impact on Beaufort Sea bowhead whales, as well as any other species that may depend on *L. macrurus as a food source*. For example, Arctic and least cisco, Arctic charr, Arctic cod and broad whitefish all feed on copepods to varying degrees.

Experimental Use of Aerial Photogrammetry to Assess the Long-term Responses of Bowhead Whales to Offshore Industrial Activities in the Canadian Beaufort Sea, 1984

BREAM PROJECT OVERVIEW NO. B1-12

PRINCIPAL INVESTIGATORS:	R.A. Davis, W.R. Koski and G.W. Miller
AFFILIATION:	LGL Limited
FUNDING SOURCE:	Northern Environment Directorate, Indian and Northern Affairs Canada
COMPLETION DATE:	1986
RELEVANT HYPOTHESIS NO.:	BEMP 1

BRIEF PROJECT DESCRIPTION

This study tested low-level aerial photography as a method to individually identify, measure and track bowhead whales, and to examine the effects of offshore industrial activities on the long-term occurrence and movements of bowheads in the Canadian Beaufort Sea. The data were collected from areas of industrial activity (Yukon coast and Mackenzie Delta area), and in control areas remote from these activities (Franklin Bay). The specific questions that this study sought to answer were as follows.

1. Do individual bowheads remain near industrial sites for prolonged periods? Resightings of whales near industrial sites would demonstrate tolerance of the industrial activity by at least a limited number of whales. The within-year resighting rates in 1984 were significantly higher, and the imputed rates of movement were lower in the control area than in areas adjacent to industrial activities. Although the data are few, they suggest that whales in the area adjacent to industrial activities moved more rapidly than those in control areas. The cause of these rapid movements is unknown; these movements may have been related to changing food supplies or to industrial disturbance, or both.

2. Do individual bowheads return in subsequent years to areas where they encountered industrial activity in a previous year? The data were too few to determine whether individual whales return in subsequent years to areas where they encountered industrial activities.

3. Do whales of different age or status react differently to industrial activities? This question is important since it provides an indication of what proportion of the bowhead population is actually exposed to offshore industrial activity in the Beaufort Sea. The data were too few to examine the relationship between a whale's length and status (age, maturity, sex) and its occurrence near industrial activities.

4. Are bowheads in the industrial area a representative sample of the western Arctic population? The few whales in the industrial area in 1984 appeared to be representative of the western Arctic population. Within the industrial area, small whales were found in the shallow nearshore areas and medium and large whales were found in offshore areas.

5. Life history data. An additional objective of this study was to increase the sample size of measured and re-identified whales. Length measurements were obtained for 391 different whales, and 186 different whales were photographed well enough to be re-identified in future years.

Censuses of the bowheads were made during the aerial surveys. Large numbers of whales were found in Franklin Bay, along the interface between the muddy Mackenzie Delta waters and clear offshore waters, and along the Yukon coast. Most of the bowheads in Franklin Bay were either adults or large immature whales. In contrast, almost all of the whales observed along the interface and Yukon coast were immature. Few calves and few potentially breeding adult whales were photographed during the 1984 studies.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This report addresses BEMP Hypothesis No. 1, particularly Links 1a, 1, 2, 3 and 4, by investigating the long-term behavioural reactions of individual bowheads to industrial activities.

Behavioural studies in the Beaufort Sea have shown that bowheads sometimes react to industry-related disturbance (e.g., approaching ships, operating seismic vessels, drilling and dredging noises). It is not known, however, whether these brief interruptions of normal whale activities have any lasting effects, or whether the individuals displaced later returned to the locations where they encountered the disturbance. The ability to recognize individual animals and to determine their relative age (i.e., length) allows examination of how individual whales, and various age classes of whales, react to industrial activities on a longer-term basis. If it can be shown that some individual whales remain in ensonified areas for prolonged periods, one could conclude that they can adapt to those types of industrial activities. However, if individuals are present only for brief periods of time, and are replaced by other individuals, then the observations do not indicate that tolerance and habituation occur. The results of this study do not conclusively answer these questions, but do establish a collection of observations and photographs of re-identifiable whales for future work.

REFERENCE

Davis, R.A., W.R. Koski and G.W. Miller. 1986. Experimental use of aerial photogrammetry to assess the long term responses of bowhead whales to offshore industrial activities in the Canadian Beaufort Sea, 1984. Environmental Studies No. 44. Northern Affairs Program, Department of Indian and Northern Affairs, Ottawa. 157 p.

Reproduction in the Bowhead Whale, Summer 1985

BREAM PROJECT OVERVIEW NO. B1-13

PRINCIPAL INVESTIGATORS:	R.A. Davis, W.R. Koski and G.W. Miller
AFFILIATION:	LGL Limited
FUNDING SOURCE:	Alaska Oil and Gas Association, U.S. NMFS, U.S. Marine Mammal Commission, North Slope Borough, INAC, and DFO
COMPLETION DATE:	1986
RELEVANT HYPOTHESIS NO.:	BEMP 1

BRIEF PROJECT DESCRIPTION

This study was designed and conducted to determine the gross annual reproductive rate (GARR) of the western Arctic bowhead whale population. This was done by photographing a large number of whales, including calves, in their summer range in the Canadian Beaufort Sea and Amundsen Gulf using aerial photography. Standardized aerial surveys were also conducted to obtain numerical estimates of the bowhead whale population. Unfortunately, severe ice conditions and poor weather conditions hampered the effectiveness of the study.

The estimated numbers of whales present in the study area in August 1985 were substantially lower than the then current population estimate of about 4500 animals. The unusually heavy ice conditions in the Beaufort Sea in 1985 apparently caused major shifts from the normal patterns of summer whale distribution. Results of the aerial photography suggested that the actively breeding segment (adults with calves) of the population was essentially absent from the study area in 1985. Estimates of the numbers of bowheads in the study area ranged from 1189 to 2251 whales.

With the absence of calves in the study area in 1985, it was not possible to obtain a direct estimate of the gross annual reproductive rate. Instead, the authors attempted to estimate GARR indirectly from the large number of presumed yearlings that were photographed, mainly near the Yukon coast. This allowed an estimate of the proportion of the population that consisted of yearlings, and thus GARR after first year mortality had been accounted for. The estimated size of the yearling class was quite high – 7.4% to 16.0% of a total estimated population of 4500 animals. Estimates of GARR from these data were also high. The calculations suggested that the reproductive rate of bowheads is higher than previously thought and/or the population size is greater than 4500 animals. [Later studies have shown very slow growth rates in bowheads. Therefore, the yearlings estimated in this study may have included some older age classes. Also, recent studies place the population size at about 7500 animals.]

Bowheads were not evenly distributed throughout the study area. Most of these whales were observed in three areas: off the Yukon coast, off the Tuktoyaktuk Peninsula, and in southwest Amundsen Gulf. Most were observed in the southern part of the study area, south of 71°N. Almost half of the whales seen in the second half of August were in the area from the Canada/U.S. boundary to Mackenzie Bay and within 50 km of the coast; another 20% were in southwest Amundsen Gulf. The remainder were widely distributed offshore.

A total of 1601 bowhead whale images were obtained by aerial photography during the study. Length measurements of 894 of these images were obtained. There was a substantial number of small bowheads (<11.0 m long) and a small number of adult whales (>13.0 m long) in the study area in 1985. Most of the smaller whales were photographed along the Yukon coast, whereas most adults were photographed in Franklin Bay. This segregation was real and not a result of sampling biases.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study addresses BEMP Hypothesis No. 1 by investigating aspects of the population size, distribution and reproduction of the western Arctic bowhead population. The general thrusts of research prior to this study had been to determine the present size of the bowhead population and how it might be affected by offshore industrial activity. Relatively little effort, however, had been directed toward one of the fundamental concerns – the rate of reproduction and recruitment of young animals into the population. For several years, the available data had indicated a rate of reproduction that was below the assumed mortality rate, and there were fears that the population was declining. However, recent studies have suggested that reproductive rates may be higher than previously thought.

The findings of this study raised uncertainties in whether previous estimates of GARR and the overall population size of the western Arctic stock of bowheads are too low. As such, the study has highlighted some important questions to be addressed in future work, and under more favourable research conditions.

REFERENCE

Davis, R.A., W.R. Koski, G.W. Miller, P.L. McLaren and C.R. Evans. 1986. Reproduction in the bowhead whale, summer 1985. Report from LGL Limited, King City, Ontario, for Standard Alaska Production Co. *et al.*, Anchorage, Alaska. 176 p.

Prediction of Drilling Site-specific Interaction of Industrial Acoustic Stimuli and Endangered Whales: Beaufort Sea (1985)

BREAM PROJECT OVERVIEW NO. B1-14

PRINCIPAL INVESTIGATORS:	P.R. Miles, C.I. Malme, G.W. Shepard, W.J. Richardson and J.E. Bird
AFFILIATIONS:	BBN Laboratories Incorporated and LGL Limited
FUNDING SOURCE:	U.S. Minerals Management Service
COMPLETION DATE:	1986
RELEVANT HYPOTHESIS NO.:	BEMP 1

BRIEF PROJECT DESCRIPTION

The purpose of this study was to provide information necessary to predict the range at which bowhead and gray whale behaviour is likely to be influenced by sounds produced at specific offshore drilling sites. This report presents the results of the first year of research (1985) of a two-year program.

The underwater acoustic environment and sound propagation characteristics associated with five offshore oil drilling industry sites on the continental shelf of the Alaskan Beaufort Sea were measured in mid August to mid September 1985. Analyses of these field data resulted in a compilation of ambient noise statistics, noise signatures of sources of sound associated with oil industry activities at those sites, and a quantitative ability to predict noise levels from oil industry activities as a function of distance from the sound source.

These new acoustic data were then synthesized with prior information on the behavioural responses of whales to underwater sound. For each site, "zones of influence" were derived -- those distances from the sound source when bowhead whales could be expected to detect and/or respond to the presence of industrial sounds. Depending on the specific site of interest, the zones of potential responsiveness (distance between sound source and whale) typically have a radius of 1.5 to 7.5 km for dredges, 2.5 to 13 km for tugs; 1.3 to 6.5 km for drillships, and 0.02 to 0.7 km for artificial island drilling. Some individual bowheads would respond at distances lesser or greater than these.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study addresses BEMP Hypothesis No. 1 (Links 1a and 1). It is important in that it provides information needed to develop a quantitative understanding of the extent to which industrial acoustic stimuli may influence bowhead behaviour. More specifically, new acoustic data from specific offshore drilling sites were acquired, and estimates of site-specific zones of potential noise influence were derived. The study is also important in that it documents the underwater sound environment to which the whales (and other marine mammals) are exposed.

REFERENCE

Miles, P.R., C.I. Malme, G.W. Shepard, W.J. Richardson and J.E. Bird. 1986. Prediction of drilling site-specific interaction of industrial acoustic stimuli and endangered whales: Beaufort Sea (1985). BBN Report No. 6185. OCS Study MMS 86-0046. Report from BBN Laboratories Inc., Cambridge, MA and LGL Limited, King City, Ontario, for U.S. Minerals Management Service, Anchorage, Alaska. 312 p.

Prediction of Drilling Site-specific Interaction of Industrial Acoustic Stimuli and Endangered Whales in the Alaskan Beaufort Sea

BREAM PROJECT OVERVIEW NO. B1-15

PRINCIPAL INVESTIGATORS:	P.R. Miles, C.I. Malme and W.J. Richardson
AFFILIATION:	BBN Laboratories Incorporated and LGL Limited
FUNDING SOURCE:	U.S. Minerals Management Service
COMPLETION DATE:	1987
RELEVANT HYPOTHESIS NO.:	BEMP 1

BRIEF PROJECT DESCRIPTION

This final report presents the combined results of a two-year research effort concerning industrial noise sources associated with offshore oil exploration in the Alaskan Beaufort Sea and the anticipated behavioural responses of endangered whales to those noise sources. The results from the first year of the program are summarized in the previous BREAM Project Overview. The basic purpose of the research was to estimate the distances between a sound source and whale where industrial noise may be (1) detected by whales, and (2) elicit some behavioural response. The bowhead whale was the primary focus of this research, although some attention was also given to site-specific zones of influence for gray whales. The research was conducted from mid August to mid September, 1985 and 1986, at six offshore oil drilling sites in the Alaskan Beaufort Sea.

As in the first year of the study, ambient noise statistics, industrial noise data, and sound transmission loss measurements were acquired and analyzed. The noise sources studied, and their general rank order from the most intense to the least intense were:

1. icebreaker pushing ice (heavy propeller cavitation),
2. tug(s) working (propeller cavitation),
3. icebreaker underway (open water),
4. dredge operating,
5. drillship drilling, and
6. drilling on artificial island.

The propagation of underwater sound was found to be unusually efficient over the continental shelf of the Alaskan Beaufort Sea, in comparison to that found in similar water depths in more temperate regions. It appears that this is associated with the presence of sub-bottom or subsea permafrost and over-consolidated clay layers, which provide low-loss acoustic reflection surfaces.

Two acoustic criteria were used to quantify the responses of whales to industrial noise: (1) predicted signal-to-noise ratio (S/N), and (2) absolute received sound pressure level. It is not known whether one is more important than the other in eliciting responses by bowhead and gray whales. S/N ratios of 20 and 30 dB were used as levels that triggered responses in bowheads. A variety of zones of influence were calculated for each activity at each industrial site.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study addresses Links 1a and 1 of BEMP Hypothesis No. 1. It is important that the potential for behavioural response of bowhead whales to industrial acoustic stimuli in the Alaskan Beaufort Sea be evaluated. This involves obtaining information on ambient and industrial noise characteristics, and whale behavioural responses to various noise sources. A good sampling of representative noise associated with oil industry operations in the Alaskan

Beaufort Sea was obtained during the 1985 and 1986 field seasons. The findings indicated that migrating and feeding whales are exposed to higher industrial noise levels at a given distance than would normally be expected in other geographic regions, such as the California coast. Several recommendations for future research are provided in the final report.

REFERENCE

Miles, P.W., C.I. Malme, W.J. Richardson. 1987. Prediction of drilling site-specific interaction of industrial acoustic stimuli and endangered whales in the Alaskan Beaufort Sea. BBN Rep. 6509; OCS Study MMS 87-0084; NTIS reports PB88-158498. Rep. from BBN Labs Inc., Cambridge, MA, and LGL Limited for U.S. Minerals Manage. Serv., Anchorage, AK. 341 p.

Responses of Bowhead Whales to an Offshore Drilling Operation in the Alaskan Beaufort Sea, Autumn 1986

BREAM PROJECT OVERVIEW NO. B1-16

PRINCIPAL INVESTIGATORS:	R.A. Davis, C.R. Greene, C.R. Evans, S.R. Johnson, W.R. Koski and S.R. Johnson
AFFILIATION:	LGL Limited and Greeneridge Sciences Inc.
FUNDING SOURCE:	Shell Western E & P Inc., Anchorage
COMPLETION DATE:	1987
RELEVANT HYPOTHESIS NO.:	BEMP 1

BRIEF PROJECT DESCRIPTION

This study examined the responses of migrating bowhead whales to an offshore drilling operation in the Alaskan Beaufort Sea in autumn 1986. The basic study approach was to document the behaviour of bowheads as they approached the drilling operation, and to compare the behaviour patterns when the whales were distant and undisturbed (= control) to when they were close to the operation. Underwater noise levels and sources were determined and monitored in order to relate the behaviour of the whales to the potential sources of disturbance to which they were exposed.

The principal finding of this study was that migrating bowheads appeared to avoid the offshore drilling operations. No whales were detected closer than 9.5 km from the drillship, and few bowheads were sighted closer than 15 km. There was no evidence, however, that the drilling operation (including the support vessels) acted as a barrier to migration. Whales passed both north and south of the rig. There was also no evidence that migrating whales were significantly delayed while they diverted around the drilling operation. Besides avoiding close approach, most bowheads exhibited 'no' or at most 'subtle' behavioural responses to the drilling operation. Responses did occur at distances of up to about 25 km, and bowheads did take typical evasive actions when ships approached them directly.

The spectral characteristics and levels of noise emitted by the drillship and several of the support vessels were determined for a variety of operating conditions and activities. The support vessels around the drillship were found to be major contributors to the composite noise of the drilling operation, even at long distances. Composite noise levels were higher than expected, even at distances of 11-15 km. Cumulative data on the composite noise field indicated that sound levels were raised substantially above predicted levels for sea states 0 and 6 in otherwise quiet ambient conditions. Transmission loss data generated in 1986 were used to predict the composite noise levels that would occur at greater distances. In the open water conditions that prevailed throughout most of 1986, composite noise from the drilling operation was predicted to be detectable regularly above ambient at distances of 20-30 km and less regularly out to 40 km. Under conditions of 3/10 ice cover with irregular pans, it was predicted that industrial noise would rarely be detectable even 20 km from the source, although there would be increases in radiated noise associated with icebreaking activities.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

All the links of BEMP Hypothesis No. 1 are addressed in this report, although the study results are most directly related to Links 1, 4, and 6.

This study represented the first direct attempt to document if and how bowheads would react to the presence of an offshore drilling operation in their fall migration path. The bowhead fall migration (routes and timing) had been studied since 1979, but drilling had not been allowed during fall migration through these waters partly because of concern that noise from the drilling activities might negatively affect the whales. The validity of this concern had never been examined. The finding that bowheads do apparently avoid the area of drilling operation is important. To put it in perspective, however, the extra time and energy taken to divert around the operation in this 1986 case would seem to have been biologically inconsequential in terms of the annual energy budget of an individual whale.

Several important behavioural observations were made. The weak behavioural responses to the drilling operation were expected since the whales avoided close approach to the drilling operation where responses might have been greater. Nevertheless, the observation that responses occurred at distances of up to about 25 km was unexpected based on studies on the summering grounds. It appears that fall migrating animals are more sensitive to potential disturbance. Response levels to directly approaching ships were typical of, and thus supported, those found during earlier studies in the Canadian Beaufort Sea.

This study was also important in that it documented the underwater sound environment to which the whales were exposed, both in the presence of and in the absence of the industrial activity. Of particular relevance are the measurements of radiated noise from the various components of the drilling operation and the long-term measurements of the composite noise from the operation. The composite noise field around the operation determines the size of the potential zone of influence of the drilling operation.

There had been concern regarding whether offshore drilling during the fall bowhead migration might adversely affect the aboriginal whale hunt. The 1986 hunt was the most successful in recent years, and it appears that the offshore drilling did not interfere with this activity.

REFERENCE

LGL Limited and Greeneridge Sciences Inc. 1987. Responses of bowhead whales to an offshore drilling operation in the Alaskan Beaufort Sea, autumn 1986. Report from LGL Ltd, King City, Ontario and Greeneridge Sciences Inc., Santa Barbara, California for Shell Western E & P Inc., Anchorage, Alaska. 371 p.

The Potential Effects of Tanker Traffic on the Bowhead Whale in the Beaufort Sea

BREAM PROJECT OVERVIEW NO. B1-17

PRINCIPAL INVESTIGATORS:	W.R. Koski, G.W. Miller and R.A. Davis
AFFILIATION:	LGL Limited
FUNDING SOURCE:	Northern Affairs Program, Department of Indian Affairs and Northern Development
COMPLETION DATE:	1988
RELEVANT HYPOTHESIS NO.:	BEMP 1 and 21

BRIEF PROJECT DESCRIPTION

This report presents the data collected during various bowhead whale studies that have been conducted in the Beaufort Sea since 1980. This integration of data was used to examine the possible effects of the proposed initial production of crude oil from the Amauligak structure, about 50 km north of the Mackenzie River delta, and its transport by shuttle tanker to a large oil tanker stationed off the northwest coast of Alaska. Ten areas of concern were examined.

1. Tanker traffic and calf-rearing areas. Review of all available data showed that a tanker route extending west from Amauligak would have influenced large numbers of calves in summer in only one (1982) of the seven years with data. Cows and calves migrate through the Alaskan Beaufort Sea primarily in late September, but are fairly widespread through nearshore and offshore waters at that time and concentrations are uncommon.

2. Exposure of particular age segments of the population to tanker traffic. Age segregation patterns were found to be very pronounced but also very complex and variable. The waters west of Amauligak are occupied in August and September of most years by the 'small and medium subadult' component of the population. In some years (1985 for example), virtually the entire subadult component of the population is present in this area. In most years, summering adults occur farther east (southwest Amundsen Gulf) and farther offshore.

3. Effects of age on bowhead behaviour. Given the pronounced age segregation found on the summering grounds, this section of the report investigated whether the various age classes of bowheads have different patterns of normal behaviour and/or responses to disturbance. Sample sizes were not sufficient to fully address this, but it was clear that the behaviour of bowheads in deep water was statistically different than in shallow water and older, larger whales tended to occur in the deeper water.

4. Photo identification file and data base. As a consequence of this study, a complete inventory of all re-identifiable bowhead photographs from the western Arctic summering grounds was established, accompanied by a computerized data base containing all relevant information about the photographs, whale lengths and re-identifications.

5. Same-day movements of bowheads. Analysis of the locations of whales rephotographed on the same day indicated that even undisturbed non-migratory whales averaged net rates of movement of about 2 km/h.

6. Site fidelity within a season. Analysis of whales resighted on more than one day within a season indicated that whales tended to remain within a particular zone while on the summering grounds. There was little evidence that individual whales associated with each other for extended periods (e.g., several days).

7. Between-year site fidelity. There was some evidence that individuals return to the same area in subsequent years: adults to the Franklin Bay area, and subadults along the Yukon coast and the edge of the Mackenzie plume.

8. Known effects of ship traffic. The data on responses of bowheads to ships were reviewed and quantified, where possible. Bowheads clearly respond to approaching ships with overt responses beginning at distances of 1 to 7 km. Bowheads seem to move up to 6 km to the side of the track of a passing ship, with reactions diminishing soon after the ship starts to move away. These evasive movements are conducted at 3-10 km/h and take 0.5 to 2 hours.

9. Separation of cow-calf pairs. The available data on whale response criteria, whale calls, ship noises, transmission loss, and ambient noise were modelled to assess the likelihood of cow-calf separation.

10. Interference with bowhead movements. The available information on hunting areas, whale distribution, and reactions to ships was assessed.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study, being of a broad nature, addresses several links in BEMP Hypothesis No. 1, particularly Links 2, 3 and 4. It also pertains directly to BEMP Hypothesis No. 21, Links 1, 2, 5, 6 and 8.

1. Tanker traffic and calf-rearing areas. Based on data from 1986, the BEMP workshop expressed concern that the proposed tanker traffic from Amauligak would traverse an important calf-rearing area. The available data indicate that detrimental effects would be unlikely, or of uncommon occurrence.

2. Exposure of particular age segments of the population to tanker traffic. Significant portions of the subadult component of the population would be exposed to ship noise from the proposed tanker traffic, whereas in most years few summering adults would be exposed to noise since they occur farther east and farther offshore. However, adults would be affected in some years (e.g., 1982) and during fall migration off the Yukon and Alaska coasts.

3. Effects of age on bowhead behaviour. Any analysis of the effects of ship traffic in the Beaufort Sea on whale behaviour must be able to relate the observed responses of whales to known patterns of normal behaviour in undisturbed situations. This aspect of the study dealt with whether the various age classes, so distinctly segregated on the summering grounds, exhibited different patterns of normal behaviour and/or responses to disturbance. Although sample sizes were not sufficient to fully address this, it was evident that any future study of the effects of tanker traffic on whale behaviour must account for the influences of water depth and, probably, whale size (= age).

4. Photo identification file and data base. A valuable collection of aerial photographs of re-identifiable whales, with accompanying data base, is now organized and available for future BREAM projects.

5. Same-day movements of bowheads. This question also addresses what is normal whale behaviour. Because it was found that individual whales can be expected to move several km in 1-2 hours even in the absence of a disturbance, the design of 'tanker effect' studies must allow for these normal patterns of local movement to prevent improperly classifying natural movements as responses to tankers.

6. Site fidelity within a season. The fact that individual whales tend to show seasonal site fidelity and remain within a particular zone while on the summering grounds has important implications. Whales that summer in areas traversed by the tanker route are likely to remain in the area and be repeatedly disturbed during the course of the summer. Other animals that summer to the north and east of the tanker route would remain there and probably not be disturbed, except perhaps when they undertake fall migration. Consequently, different subgroups of the summering population could be disproportionately affected. The potential for tanker-related disturbances to disrupt bowhead groups appears to be of little concern as the evidence indicates that these groups naturally form and break up regularly.

7. Between-year site fidelity. This question examines the longer-term patterns of bowhead site fidelity, and thus the longer-term potential effects of tanker traffic. There was some evidence that bowheads return to the same areas in subsequent years. Consequently, it was determined that the adult component of the population would not be exposed to ship traffic but the subadult component would be subject to repeated disturbance over a number of years.

8. Known effects of ship traffic. Because of the similarity in distances moved by whales to avoid ships and those normally carried out, extreme care is needed when studying and interpreting short-term responses of bowheads to ship traffic.

9. Separation of cow-calf pairs. The BEMP workshop identified the possibility that cow-calf pairs might become permanently separated if tanker noise prevented communication between the cow and the calf. The results indicate that permanent separation is very unlikely.

10. Interference with bowhead movements. Concern has been expressed by BEMP workshop participants and others that tanker traffic might cause whale displacement that would interfere with the coastal harvest in Alaska during fall. Available information indicates that on most passages the tanker will be too far offshore to affect the huntable nearshore whales. If whales are forced closer to

shore, by offshore ice conditions for example, the tanker may have some effects on the whale hunt. These effects could be beneficial or detrimental, depending how close the tanker is to shore.

REFERENCE

Koski, W.R., G.W. Miller and R.A. Davis. 1988. The potential effects of tanker traffic on the bowhead whale in the Beaufort Sea. Report from LGL Ltd, King City, Ontario for Department of Indian Affairs and Northern Development, Hull, Quebec. 150 p.

Industry Observations of Bowhead Whales in the Canadian Beaufort Sea, 1976-1985

BREAM PROJECT OVERVIEW NO. B1-18

PRINCIPAL INVESTIGATORS:	J.G. Ward and E. Pessah
AFFILIATION:	Dome Petroleum Ltd.
FUNDING SOURCE:	Dome Petroleum Ltd.
COMPLETION DATE:	1988
RELEVANT HYPOTHESIS NO.:	BEMP 1

BRIEF PROJECT DESCRIPTION

In 1976, Canadian Marine Drilling Ltd. (CANMAR) began exploratory drilling in the deeper offshore waters of the Canadian Beaufort Sea. As part of the terms and conditions of the regulatory approval for this activity, personnel involved with the drilling were requested to record incidental sightings of wildlife in general, and marine mammals in particular. This paper summarizes all the bowhead whale sightings recorded during this program between 1976 to 1985. The results were analysed, along with historical data and data from other more recent studies, to examine the suggestion of a trend of decreasing use of the industrial zone by bowheads as a result of oil and gas exploration activities.

Data of incidental whale sightings from 1976 to 1985 together with results of other studies suggests that (1) bowheads were widely abundant in the exploration zone only in 1980 and 1981, (2) localized concentrations occurred in the industrial zone in 1976, 1977, 1983 and 1984, and (3) bowheads were largely absent from this zone in 1978, 1979, 1982 and 1985. In addition, historical whaling records indicated that bowhead whales were not abundant in the area now known as the main industrial area in the late 1800s and early 1900s.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study addresses BEMP Hypothesis No. 1, Links 1a, 1 and 2. The Canmar incidental sightings data on bowhead whales provide further information on the relative abundance or absence of bowheads within the industrial zone. Together with historical information, the data do not support the suggestion of a trend of decreasing use of the exploration area by bowheads. [It is important to note that the observations are not directly comparable from year to year, particularly for the early years.]

REFERENCE

Ward, J.G. and E. Pessah. 1988. Industry observations of bowhead whales in the Canadian Beaufort Sea, 1976-1985. Pages 75-88. *In:* W.M. Sackinger *et al.* (eds.). Port and Ocean Engineering under Arctic Conditions, Volume II. Geophysical Institute, University of Alaska, Fairbanks, AK. 111 p.

Comparison of Behaviour of Bowhead Whales of the Davis Strait and Bering/Beaufort Stocks

BREAM PROJECT OVERVIEW NO. B1-19

PRINCIPAL INVESTIGATORS:	W.J. Richardson and K.J. Finley
AFFILIATION:	LGL Limited
FUNDING SOURCE:	U.S. Minerals Management Service
COMPLETION DATE:	1989
RELEVANT HYPOTHESIS NO.:	BEMP 1

BRIEF PROJECT DESCRIPTION

This was the first of a two-phase study to compare the behaviour of bowhead whales in the western Arctic (Bering/Beaufort stock) and in the eastern Arctic (Davis Strait/Baffin Bay stock) to determine whether differences in behaviour could be attributed to the presumed higher levels of human activities in the western Arctic. In Phase 1 (this report), behavioural data collected in the absence of known sources of potential disturbance were used to compare normal behaviour of Davis Strait/Baffin Bay vs. Bering/Beaufort bowheads. These data came from previous studies, and included previously-unanalysed eastern Arctic data. Phase 2 (Miller *et al*. 1991; see next BREAM Project Overview) consisted of a detailed evaluation of the levels of human activity and potential disturbance to which each stock was exposed, and an integration of the two studies.

In Phase 1, the behavioural repertoires in the two regions were qualitatively similar in most respects, but there were some statistically significant quantitative differences. These differences were evident for all three categories of whales that were compared: whales feeding in deep water, whales socializing in shallow water, and whales migrating during autumn. Multivariate and other analyses indicated that some but not all of these differences could be ascribed to regional differences in environmental conditions or whale activities. The regional differences in the behaviour of feeding and socializing whales could most easily be explained by the substantial differences in water depth and age of the animals, respectively. The surfacing-dive cycles of whales feeding in deep (>50 m) water were much more protracted in the eastern Arctic than in the west, with many more respirations per surfacing. Socializing was much more active, and obvious sexual interactions were much more common, at the Isabella Bay area of the eastern Arctic than at any location in the western Arctic during late summer or autumn. Behaviour of migrating bowheads in the two regions was generally similar. However, dive durations were considerably greater in the west, and fluke-out dives were more common in the east.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

As this study investigated the long-term cumulative effects of human disturbance on bowhead populations, it was fundamental to addressing all links in BEMP Hypothesis No. 1.

The Phase 1 report provides the first detailed quantitative data on the behaviour of the Davis Strait bowheads, and indeed on any bowhead stock other than the much-studied Bering/Beaufort population. This has allowed comparisons of the behaviour patterns of these two isolated populations. It has revealed, for example, that there may be real differences in reproductive activities between the two stocks. This difference is potentially important with regard to the dynamics of the two populations. Additional differences in behaviour, and correlations with human activities, are discussed in the overview of Phase 2 of this study (see next BREAM Project Overview).

REFERENCE

Richardson, W.J. and K.J. Finley. 1989. Comparison of behaviour of bowhead whales of the Davis Strait and Bering/Beaufort stocks. OCS Study MMS 88-0056. Report from LGL Limited, King City, Ontario for U.S. Minerals Management Service, Herndon, Virginia. 131 p.

Behaviour of Bowhead Whales of the Davis Strait and Bering/Beaufort Stocks vs. Regional Differences in Human Activities

BREAM PROJECT OVERVIEW NO. B1-20

PRINCIPAL INVESTIGATORS:	G.W. Miller, R.A. Davis and W.J. Richardson
AFFILIATION:	LGL Limited
FUNDING SOURCE:	U.S. Minerals Management Service
COMPLETION DATE:	1991
RELEVANT HYPOTHESIS NO.:	BEMP 1

BRIEF PROJECT DESCRIPTION

This was the second, and last phase of a study to compare the behaviour of bowhead whales in the western Arctic and in the eastern Arctic to determine whether differences in behaviour could be attributed to the higher levels of human activities in the western Arctic. Phase 1 (Richardson and Finley 1989; see previous BREAM Project Overview) consisted of a quantitative comparison of bowhead behaviour in the two regions. It documented several statistically-significant differences between the two stocks. Phase 2 consisted of a detailed evaluation of the levels of human activity and potential disturbance to which each stock was exposed, and the integration of these data with the behavioural observations of Phase 1.

The relative exposure of the two stocks to several categories of human activities was assessed for the 13-year period from 1974-1986; a period that includes the years of significant oil industry activity in the eastern and western Arctic. The most intense, and potentially most disturbing, human activities are subsistence whaling, commercial vessel traffic and marine seismic exploration. These activities were much more prevalent in the Bering/Beaufort stock area than in the Davis Strait stock area. Based on the numerical assessments of disturbance levels and the relative importance of each type, it was concluded that bowheads of the Bering/Beaufort stock have been subjected to at least 3 to 5 times as much disturbance as have bowheads of the Davis Strait stock.

When the results of Phases 1 and 2 were integrated, it was concluded that most of the differences in behaviour between the two stocks were better explained by environmental or biological factors than by disturbance. Nevertheless, the behaviour of fall migrating bowheads was statistically different: bowheads of the Bering/Beaufort stock were less conspicuous (less time spent at the surface and fewer fluke-out dives). This may have been a response to subsistence whaling in the Beaufort Sea. There was no evidence that Bering/Beaufort bowheads habituated to the higher levels of human activity.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study examined the long-term cumulative effects of underwater noise and other stimuli associated with industrial activity on the behaviour and long-term well-being of bowheads. In contrast, most studies to date had investigated the short-term behavioural responses of whales to industrial activities. This study is fundamental to addressing all links of BEMP Hypothesis No. 1.

In recent years, there were indications that part of the bowhead summering range where offshore oil exploration had been in progress over the past decade was not being used as extensively. Was this evidence of a long-term population response to the industrial activity? Effective studies of the possible long-term reactions of a population of whales to such human activities are difficult to do. This study took a new approach by comparing the behaviour of a bowhead population less exposed to recent human activity (a control population, the Davis Strait/Baffin Bay stock) with that of the more exposed Bering/Beaufort stock.

REFERENCE

Miller, G.W., R.A. Davis and W.J. Richardson. 1991. Behaviour of bowhead whales of the Davis Strait and Bering/Beaufort stocks vs. regional differences in human activities. Report by LGL Limited, King City, Ontario for U.S. Minerals Management Service, Herndon, Virginia. 122 p.

Bowhead Whale (*Balaena mysticetus*) Growth and Feeding as Estimated by $\partial^{13}C$ Techniques

BREAM PROJECT OVERVIEW NO. B1-21

PRINCIPAL INVESTIGATORS:	D.M. Schell, S.M. Saupe and N. Haubenstock
AFFILIATION:	University of Alaska
FUNDING SOURCES:	U.S. Minerals Management Service and University of Alaska
COMPLETION DATE:	1989
RELEVANT HYPOTHESIS NO.:	BEMP 1

BRIEF PROJECT DESCRIPTION

This paper reports on a study of carbon isotope ratios in bowhead whale muscle, visceral fat and baleen tissues. Carbon isotope values change seasonally in bowhead body tissues. These changes correspond to geographic variations in the carbon isotope content of zooplankton prey organisms consumed along the annual migratory route of bowheads, between the wintering areas in the Bering and Chukchi Seas, and the summering area in the Canadian Beaufort Sea. Consequently, isotope ratios in baleen and body tissues can be used to provide information on bowhead growth rates and feeding habits in the various habitats and geographic areas which they occupy. During this study, samples of baleen, muscle and visceral fat were collected from 12 bowhead whales killed by Alaskan Inupiat during the 1986 spring and fall whaling hunts.

The study findings suggest that large (adult) bowheads acquire most of their food from fall and winter feeding, or from parts of their summer range where zooplankton are enriched in $\partial^{13}C$. They do not show significant seasonal shifts in the carbon isotope values of muscle and visceral tissue. Young animals, however, were found to undergo marked seasonal shifts, suggesting that they feed extensively on both their summer range (where prey sampled to date have had low $\partial^{13}C$ values) and autumn/winter ranges (where the zooplankton prey are enriched in $\partial^{13}C$).

Oscillations in $\partial^{13}C$ along the length of the baleen allows the age of the whales to be determined. The results of this analysis indicate that bowheads are slow growing, taking about 20 years to reach breeding size. Growth rates of bowheads are slow (about 0.4 m per year) after their first year. Baleen length is a good field indicator of age in young whales (<14 years), whereas body length is poorly correlated particularly during the first 8 to 10 years of life.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study is of fundamental relevance to BEMP Hypothesis No. 1, as it provides new data for the determination of ages, growth rates and recruitment in the Bering/Beaufort stock of bowhead whales. It also provides important findings on the possibly different feeding habits of subadult and adult bowheads. This study addresses links concerned with feeding (6, 7) and population parameters (8) of BEMP Hypothesis No. 1. If these findings are valid, then they raise serious questions about the basic energetic models used in the early years of BEMP.

REFERENCE

Schell, D.M., S.M. Saupe and N. Haubenstock. 1989. Bowhead whale (*Balaena mysticetus*) growth and feeding as estimated by $\partial^{13}C$ techniques. Marine Biology 103: 433-443.

Movements and Behaviours of Bowhead Whales in Response to Repeated Exposures to Noises Associated with Industrial Activities in the Beaufort Sea

BREAM PROJECT OVERVIEW NO. B1-22

PRINCIPAL INVESTIGATORS:	D. Wartzok[1], W.A. Watkins[2], B. Würsig[3] and C.I. Malme[4]
AFFILIATIONS:	[1]Purdue University, [2]Woods Hole Oceanographic Institution, [3]Moss Landing Marine Laboratory, and [4]BBN Systems and Technologies Corp.
FUNDING SOURCE:	Amoco Production Company
COMPLETION DATE:	1989
RELEVANT HYPOTHESIS NO.:	BEMP 1 and 21

BRIEF PROJECT DESCRIPTION

This volume reports on the findings of the first year (1988) of a two-year field study of bowhead whales in the Beaufort Sea. Aerial and ship-based observations were made on bowhead distribution, abundance, behaviour and responses to playback of industrial noise. Acoustic studies were also carried out. A total of 9 bowheads were tagged, and detailed trackings were obtained on two of these animals.

Results of the two years of field work are discussed in the following BREAM Project Overview.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study addresses BEMP Hypotheses Nos. 1 and 21, particularly those links concerned with reactions of bowhead whales to industrial noises (Links 1a, 1, 2, 3, and 4 of BEMP Hypothesis No. 1; and Links 1, 2, 5, and 6 of BEMP Hypothesis No. 21).

REFERENCE

Wartzok, D., W.A. Watkins, B. Würsig and C.I. Malme. 1989. Movements and behaviours of bowhead whales in response to repeated exposures to noises associated with industrial activities in the Beaufort Sea. Rep. from Purdue Univ., Fort Wayne, IN, for Amoco Production Co., Anchorage, AK. 228 p.

Movements and Behaviour of Bowhead Whales

BREAM PROJECT OVERVIEW NO. B1-23

PRINCIPAL INVESTIGATORS:	[1]D. Wartzok, [2]W.A. Watkins, [3]B. Würsig, [4]J. Guerrero and [5]J. Schoenherr
AFFILIATIONS:	[1]Purdue University, [2]Woods Hole Oceanographic Institution, [3]Texas A & M University at Galveston, [4]Moss Landing Marine Laboratories, and [5]University of Rhode Island
FUNDING SOURCE:	Amoco Production Company
COMPLETION DATE:	1990
RELEVANT HYPOTHESIS NO.:	BEMP 1 and 21

BRIEF PROJECT DESCRIPTION

This report presents the results of a two-year study initiated in 1988 (see previous BREAM Project Overview), which utilized radio tagging to identify, track and study individual bowhead whales in the Canadian Beaufort Sea. The study found that bowhead whales can be approached and tagged with implantable radio transmitters. The tags provided individual recognition of the whales, allowed monitoring of behaviour, activity and movements of individual whales, and facilitated playback experiments and feeding studies on tagged animals and their companions. The playback experiments conducted in 1988 were replaced by feeding studies in 1989. Conclusions based on both years of data are presented.

During the two years of this study, six bowhead whales were tracked for a total of 7017 km. Five of these whales were followed over major portions of their westward migration through the Canadian and Alaskan Beaufort Sea. Average travelling speeds were calculated for each of these whales. Most of the observed feeding behaviour occurred near the 20 m contour. Some whales followed the 20 m contour quite closely on their migration, while others migrated beyond the 100 m contour. All six tagged whales crossed the U.S./Canada border between 21 and 25 September of both years (two years with very different ice conditions).

Because the radio-tagged whales respond to the same environmental and social cues as do the rest of the population, it was possible to observe the responses of over 200 whales to the noises of either the tracking and tagging ship, or playback of the Kulluk drilling platform. The whales appeared to be remarkably tolerant of steady sources of noise, showing disturbance responses primarily to rapid changes in noise levels. Within this general pattern of noise response, there were individual differences ranging from whales that moved away from the ship when it was several km distant, to feeding whales that swam into the side of the ship while it was either stationary or making zooplankton net tows.

Tracking of tagged whales led the investigators to, or kept them near, whale concentrations. Consequently, it was possible to obtain data on prey species and densities at the location and time when the whales were feeding. This allowed comparisons to be made on zooplankton types and densities away from the whales, and observations of prey type with feeding pattern. The mean biomass of zooplankton in the presence of whales was significantly greater than it was in their absence, and the number of whales observed was correlated with the sampled biomass of prey organisms. Diving in an area where whales surfaced with mud streaming from their baleen revealed little benthic fauna. However, mysids and copepods were found in the muddy water near the bottom -- the whales were nearbottom feeding rather than bottom feeding. Radio tagging also allowed the investigators to locate and observe social behaviour and obtain acoustic recordings of bowheads engaged in social behaviour and sexual activity.

The thousands of dive times obtained on the radio-tagged whales showed individual, diurnal and behaviour-specific patterns.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

Together with the first year's results, these studies address BEMP Hypotheses Nos. 1 and 21. The 1988 results address those links concerned with short-term reactions of bowheads to industrial noises, in particular Links 1a, 1, 2, 3, and 4 of BEMP Hypothesis No. 1 and Links 1, 2, 5, and 6 of BEMP Hypothesis No. 21. The 1989 field studies shifted importance to feeding studies rather than playback experiments. While not focussed directly on any of the linkages, the results provide important new baseline data on bowhead ecology and behaviour.

Findings of particular interest include the following.

1. Sexual activity of the magnitude observed in 1988 had not been previously described for fall migrating bowheads in the western Arctic.

2. The data on dive times suggest that caution should be exercised in interpreting changes in diving patterns without consideration of all the factors that contribute to the diving behaviour of whales.

3. Because the investigators were able to follow tagged whales and thus be led to other whales, playback were presented to more whales than had been exposed in previous playback studies. The findings were essentially the same as earlier studies, which provides additional confirmation of those earlier results.

The ability to identify and track individual whales for relatively long periods, both from the air and close at hand from a ship, provided information that would have otherwise been very difficult to obtain. This study has shown that questions on feeding, social behaviour and responses to disturbance can be addressed using conventional radio tracking with a combination of ship-based and aerial observers.

REFERENCE

Wartzok, D., W.A. Watkins, B. Würsig, J. Guerrero and J. Schoenherr. 1990. Movements and behaviours of bowhead whales. Rep. from Purdue Univ., Fort Wayne, IN, for Amoco Production Co., Anchorage, AK. 197 p.

Industry-sponsored Bowhead Whale Monitoring and Research in the U.S. and Canadian Beaufort Sea

BREAM PROJECT OVERVIEW NO. B1-24

PRINCIPAL INVESTIGATOR:	D. Wartzok
AFFILIATION:	Purdue University
FUNDING SOURCE:	Amoco Production Company
COMPLETION DATE:	1990
RELEVANT HYPOTHESIS NO.:	BEMP 1

BRIEF PROJECT DESCRIPTION

This conference paper presented summary results of a study of radio-tagged bowheads in the Canadian Beaufort Sea in 1988 and 1989. The tags provided individual recognition of the whales, allowed extended monitoring of the behaviour, activity and movements of individual whales, and facilitated playback experiments and feeding studies on tagged animals and their companions. The project is described more fully in the previous BREAM Project Overview, the original report of the second year of the study.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study addresses BEMP Hypothesis No. 1. While not focussed directly on any of the linkages, the results provide baseline data on feeding and migratory behaviour. The ability to identify and track individual whales for relatively long periods provides information that is otherwise very difficult to obtain. The playback experiments address Links 1a and 1, with respect to short-term behavioural responses to offshore drilling noises.

REFERENCE

Wartzok, D. 1990. Industry-sponsored bowhead whale monitoring and research in the U.S. and Canadian Beaufort Sea. Pages 33-40. *In:* Alaska OCS Region Third Information Transfer Meeting Conference Proceedings. Jan. 30-Feb 1, 1990, Anchorage, Alaska. 230 p.

Analysis and Ranking of the Acoustic Disturbance Potential of Petroleum Industry Activities and other Sources of Noise in the Environment of Marine Mammals in Alaska

BREAM PROJECT OVERVIEW NO. B1-25

PRINCIPAL INVESTIGATORS:	[1]C.I. Malme, [1]P.R. Miles, [2]G.W. Miller, [2]W.J. Richardson, [2]D.G. Roseneau, [2]D.H. Thomson and [3]C.R. Greene, Jr.
AFFILIATIONS:	[1]BBN Systems and Technologies Corp., [2]LGL Limited, and [3]Greeneridge Sciences Inc.
FUNDING SOURCE:	U.S. Minerals Management Service
COMPLETION DATE:	1989
RELEVANT HYPOTHESIS NO.:	BEMP 1, 2, 3, 5 and 21

BRIEF PROJECT DESCRIPTION

The purpose of this study was to provide an up-to-date comprehensive synthesis of available information that compared the relative magnitudes and effects of noise from oil and gas industry activities on marine mammals with noise from other sources in Alaskan outer continental shelf and coastal waters.

Thirty species of marine mammals known to occur in Alaska were considered in the study, including baleen whales, toothed whales, seals and walrus. Information on the Alaskan distribution and abundance of these species was combined with information on noise source distribution, noise source level, and transmission loss to determine the most significant noise sources in terms of their acoustic ranges and the numbers of mammals potentially affected. This was done by developing a Standardized Noise Contribution Model and a Standardized Exposure Rating Model. The noise model is based on the acoustic energy density contributed to the environment by a specific type of source in a defined reference area. The exposure rating model takes into account the degree of matching between the noise source bandwidth and the species' hearing sensitivity, and the number of animals present in the reference area. The result of this procedure is an indication of which source/species combinations have the highest potential for acoustic interaction in a given area.

In terms of their potential effects on marine mammals, the loudest sound sources in the Alaskan marine environment are seismic arrays (both air gun and vibroseis), icebreakers, large ships, and dredges. Sound levels produced by the smaller vessels used for cargo hauling, fishing and recreation become significant when several vessels are operating in a relatively small area. Earthquake events produce high underwater sound levels sporadically in active seismic areas. Sound produced by aircraft is the loudest airborne noise component, but the primary impact of this noise is near airports and landing strips, and along routes where low altitude operations are prevalent.

Baleen whales are believed to have hearing sensitivity characteristics that include the frequency ranges of most of the man-made sources discussed in the report. As a result, the gray, bowhead, fin and humpback whales were predicted to be the species with the highest probabilities of acoustic interaction with most of the sound sources studied. The model predicted that there would be less of a probability of acoustic influence on the other species studied. This is primarily a result of the fact that their optimal hearing sensitivities are at frequencies outside the dominant frequencies of most man-made sources.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

Although not concerned with the Canadian Beaufort Sea region directly, this report does provide information on issues and species of concern to BREAM. To the extent that these overlap, this report is of relevance to BEMP Hypotheses Nos. 1, 2, 3, 5 and 21.

The frequency ranges and sound levels at which noise sources can affect marine mammals are not well known. This study, through a review and integration of the literature together with the modelling procedures, has developed a means of predicting and ranking some of the species and situations where noise impacts are most and least likely. This certainly has applicability to the Beaufort region.

REFERENCE

Malme, C.I., P.R. Miles, G.W. Miller, W.J. Richardson, D.G. Roseneau, D.H. Thomson and C.R. Greene, Jr. 1989. Analysis and ranking of the acoustic disturbance potential of petroleum industry activities and other sources of noise in the environment of marine mammals in Alaska. BBN Report 6945. OCS Study MMS 89-0006. Report from BBN Systems and Technologies Corp., Cambridge, MA for U.S. Minerals Management Service, Anchorage, AK.

Effects of offshore petroleum operations on cold water marine mammals: A literature review

BREAM PROJECT OVERVIEW NO. B1-26

PRINCIPAL INVESTIGATORS:	W.J. Richardson, J.P. Hickie, R.A. Davis, D.H. Thomson and C.R. Greene
AFFILIATIONS:	LGL Limited and Greeneridge Sciences Inc. (C.R. Greene)
FUNDING SOURCE:	American Petroleum Institute
COMPLETION DATE:	1989
RELEVANT HYPOTHESIS NO.:	BEMP 1-9 and 19-21

BRIEF PROJECT DESCRIPTION

This report presents a detailed review of the available literature concerning the acoustic, non-acoustic and cumulative effects of offshore petroleum operations on marine mammals. Species inhabiting Alaskan waters are emphasized, including toothed whales, baleen whales, hair seals, fur seals, sea lions, walrus, sea otter and polar bear. The world literature on related species and topics is also considered. This review is an updated version of a review first published in 1983.

The review of acoustic effects discusses background information on underwater acoustics, ambient noise, noise from petroleum industry operations, propagation of sound in water, sounds produced by marine mammals, hearing by marine mammals, documented reactions of marine mammals to industrial noise, and the sizes of zones of noise influence around industrial sites. Types of industry activities considered include aircraft and vessel traffic, icebreaking, seismic exploration, dredging and island construction, offshore drilling, and production facilities.

The review of non-acoustic effects discusses the effects of oil spills and other discharges, dredging, shock waves, icebreaking, collision hazards, general disturbance, and increased access. The report includes comments on the acoustic and non-acoustic impacts of related activities not associated with the petroleum industry, such as general ship traffic and hunting. The final section discusses the cumulative effects of multiple human activities. It also discusses the available evidence concerning tolerance of and habituation to various human activities.

The overall conclusion is as follows: Whether full-scale production from offshore oil fields will have long-term effects on northern species will remain unknown until such activity occurs and suitable monitoring studies are done. However, the limited short-term effects demonstrated to date and the survival of other species in other developed coastal areas suggest that long-term effects from oil and gas related activities may not be severe.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This major review covers literature that addresses all of the BEMP Hypotheses concerning marine mammals. It is substantially updated from the original 1983 edition. Most of the new material concerns industrial noise characteristics, marine mammal hearing, reactions to noise, zones of noise influence, and oil effects. In many cases, the new studies added for this edition have allowed more specific conclusions to be drawn than were possible in the first edition. This report is also significant in that it inspects information from non-Arctic areas and on human activities not related to the petroleum industry, and assesses their applicability. At the same time, a review of the effects of noise on marine mammals was being prepared (Richardson *et al*. 1991; see next BREAM Project Overview). Although there is substantial overlap, together these documents review the available literature in detail.

REFERENCE

Richardson, W.J., C.R. Greene, J.P. Hickie, R.A. Davis and D.H. Thomson. 1989. Effects of offshore petroleum operations on cold water marine mammals: A literature review, 2nd ed. API Publ. 4485. Am. Petrol. Inst., Washington, DC. 385 p.

Effects of Noise on Marine Mammals

BREAM PROJECT OVERVIEW NO. B1-27

PRINCIPAL INVESTIGATORS:	W.J. Richardson[1], C.R. Greene Jr.[2], C.I. Malme[3] and D.H. Thomson[1]
AFFILIATIONS:	[1]LGL Limited, Greeneridge Sciences Inc.[2], and BBN Systems and Technologies Corp.[3]
FUNDING SOURCE:	U.S. Minerals Management Services
COMPLETION DATE:	1991
RELEVANT HYPOTHESIS NO.:	BEMP 1-8 and 21

BRIEF PROJECT DESCRIPTION

This volume is a review of literature concerning the effects of man-made noise on marine mammals. Emphasis is placed on underwater noise, but some attention is given to airborne sounds. Strong emphasis is placed on the effects of noise from offshore oil and gas exploration and development, but effects of related types of man-made noise are also taken into account. The review deals primarily with effects of noise on marine mammals in U.S. coastal waters, but the worldwide literature is also considered. Formally published literature is reviewed in detail, but considerable effort was also made to review the large body of relevant research reported in technical and contract reports. This includes reviews of literature and studies unrelated to marine mammals, including basic acoustical research, studies of ship noise conducted for military purposes, and studies of aircraft noise for purposes of reducing noise around airports.

The volume is divided essentially into two parts – (1) initial introductory and background chapters on acoustic concepts and terminology, sound propagation, ambient noise, man-made noise, marine mammal sounds, and marine mammal hearing, and (2) chapters summarizing the available information and hypotheses about specific noise effects on marine mammals, documented disturbance reactions, zones of noise influence, significance of responses and noise impacts, and conclusions and data needs.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

The effects of noise on marine mammals is a fundamental concern of BREAM. Consequently, this volume is a significant and comprehensive contribution. Together with a companion review (Richardson *et al.* 1989, see previous BREAM Project Overview), these reports provide 'state-of-the-art' reviews and identify needs and hypotheses for future research.

REFERENCE

Richardson, W.J., C.R. Greene Jr., C.I. Malme and D.H. Thomson. 1991. Effects of noise on marine mammals. Report from LGL Ecological Research Associates, Inc., Bryan, TX for U.S. Minerals Management Service, Herndon, VA. 462 p.

Trophic Investigations of the Arctic Ocean and Bering Sea via Stable Isotope Analysis

BREAM PROJECT OVERVIEW NO. B1-28

PRINCIPAL INVESTIGATORS:	D.M. Schell, S.M. Saupe, N. Haubenstock and K. Vinette
AFFILIATION:	University of Alaska
FUNDING SOURCE:	U.S. Minerals Management Service and North Slope Borough
COMPLETION DATE:	1990
RELEVANT HYPOTHESIS NO.:	BEMP 1

BRIEF PROJECT DESCRIPTION

This conference paper presents a brief summary of studies using the natural ratios of carbon isotopes within the Arctic marine ecosystem to gain basic knowledge on aging, growth rates and feeding areas of bowhead whales. (Results of this study are also discussed in BREAM Project Overview No. B1-21.)

It was found that zooplankton, on which bowheads feed, exhibited a remarkable change in carbon isotope ratios over most of the range of the Bering Sea stock of bowheads. Corresponding oscillations in carbon isotope ratios were found in the baleen plates and muscle and visceral fat tissues of bowheads, reflective of the various parts of the range the whales had visited and fed in during their annual migrations. The isotope ratio oscillations along the length of the baleen plates were used to age whales. The isotope ratios in the baleen, and especially in the muscle and visceral fat, were compared to the known isotope identity of zooplankton throughout the bowhead range to indicate where the whales had fed.

Comparisons of age (determined from the baleen) and length data suggested that growth is very rapid during the first year of life, but is followed by a period of several years in which little or no growth occurs. The authors suggested that, if weaning occurs at about one year, the apparent diapause in growth may be due to a period in the life of the whale when the baleen plates are still too short for effective filter feeding and skills at capturing more mobile prey such as euphausiids are being developed. The young whales may be largely dependent upon fat reserves acquired during the first year of nursing to subsidize sub-optimal feeding during this period. By year five, the baleen plates have lengthened to where feeding becomes efficient enough to allow body growth to resume. The authors concluded that, if sexual maturity occurs at near 13 to 14 m, then bowheads may require 17 to 20 years to reach that length and begin to breed.

Analysis of isotope ratios in muscle and visceral fat suggested that adult bowheads may not feed to a significant extent in the eastern Beaufort Sea, but rather primarily in the western and southern parts of their range. Otherwise, they may be feeding in areas of the eastern Beaufort Sea, as yet unsampled, where the carbon isotope characteristics of the prey match those of the whale tissues.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study is relevant to BEMP Hypothesis No. 1. While not focussed directly on any of the linkages, the results provide important new data on feeding, growth patterns, and population dynamics that are broadly applicable to many aspects of bowhead life history.

The results raise questions about why the apparent bowhead growth pattern differs so markedly from that of the closely related right whale, and why bowheads migrate to the eastern Beaufort Sea if most of their feeding is done elsewhere? The age/length data are also revealing with regard to aging bowheads from aerial photographs. Because young bowheads grow so little in the first five years of life, a whale of a certain length may be anywhere from one to five years old. Consequently, earlier studies using measurements from whale photographs to estimate recruitment into the population require re-evaluation.

REFERENCE

Schell, D.M., S.M. Saupe, N. Haubenstock and K. Vinette. 1990. Trophic investigations of the Arctic Ocean and Bering Sea via stable isotope analysis. Pages 49-53. *In:* Alaska OCS region third information transfer meeting conference proceedings. Jan. 30-Feb 1, 1990, Anchorage, Alaska. 230 p.

Acoustic Effects of Oil Production Activities on Bowhead and White Whales Visible during Spring Migration near Pt. Barrow, Alaska – 1989 Phase: Sound Propagation and Whale Responses to Playback of Continuous Drilling Noise from an Ice Platform, as Studied in Pack Ice Conditions

BREAM PROJECT OVERVIEW NO. B1-29

PRINCIPAL INVESTIGATORS: W.J. Richardson[1], C.R. Greene[2], Jr., W.R. Koski[1], C.I. Malme[3], G.W. Miller[1], M.A. Smultea[4] and B. Würsig[4]
AFFILIATION: [1]LGL Limited, [2]Greeneridge Sciences Inc., [3]BBN Systems and Technologies Corp., and [4]Texas A&M University of Galveston
FUNDING SOURCE: U.S. Minerals Management Service
COMPLETION DATE: 1990
RELEVANT HYPOTHESIS NO.: BEMP 1 and 2

BRIEF PROJECT DESCRIPTION

The objectives of this experimental study were to: (1) quantify the physical acoustic conditions, especially rates of sound attenuation, in spring lead systems; and (2) determine the short-term behavioural responses of whales to playback of sounds from production platforms, icebreakers, and aircraft. The study was conducted from late April to late May, 1989 about 60 km ENE of Point Barrow, Alaska. An underwater sound projector was used to broadcast recorded industrial noise into the water. The reactions of approaching whales to these sounds was then observed, and sound attenuation rates were measured.

During playback experiments, low-frequency drilling noise was projected into the water. This noise was strong within about 1 km of the projector, and fairly detectable out to at least 4-5 km (occasionally to 9-10 km). Underwater sound was found to attenuate more rapidly under the pack ice conditions encountered in this study, than found previously in open waters of the Beaufort Sea during late summer.

Because of adverse ice and weather conditions encountered in 1989, sample sizes were small. Bowhead whales were observed within the area ensonified by the sound projector on five days. On four days, white whales were also observed near the operating projector. The limited data showed that some bowheads tolerated low-frequency drilling noise without interrupting or diverting their migration; others may have reacted strongly but the data were inconclusive. The authors cautioned that it would be premature to generalize these few data to the whole bowhead population or to other types of industrial sounds.

White whales migrating toward the projector travelled toward it until they came within a few hundred metres. Some then continued past it without apparent hesitation or turning. Others definitely reacted at distances on the order of 200-400 m; they slowed, milled and in some cases reversed course temporarily. However, within a few minutes, they continued past the projector, sometimes passing <50-100 m from it. There was no evidence that white whales reacted at distances >200-400 m. Again, it was cautioned that generalizations or extrapolations should not be made from these limited observations.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study addresses BEMP Hypothesis No. 1 regarding bowhead whales, and BEMP Hypothesis No. 2 regarding white whales.

Concern has been expressed that bowhead and white whales may be in potential jeopardy if oil development proceeds near spring leads through which whales migrate around northern Alaska in spring. Previous studies of the reactions of bowheads to noise from oil industry operations have all been conducted during late summer or autumn, in open water or at most light ice conditions. Although additional data are required before definite conclusions can be reached, the 1989 work did provide useful results on sound propagation and whale responses. After additional data are collected, the results of this study should be useful in assessing the acoustic effects of oil exploration and development near spring lead systems on migrating bowhead and white whales.

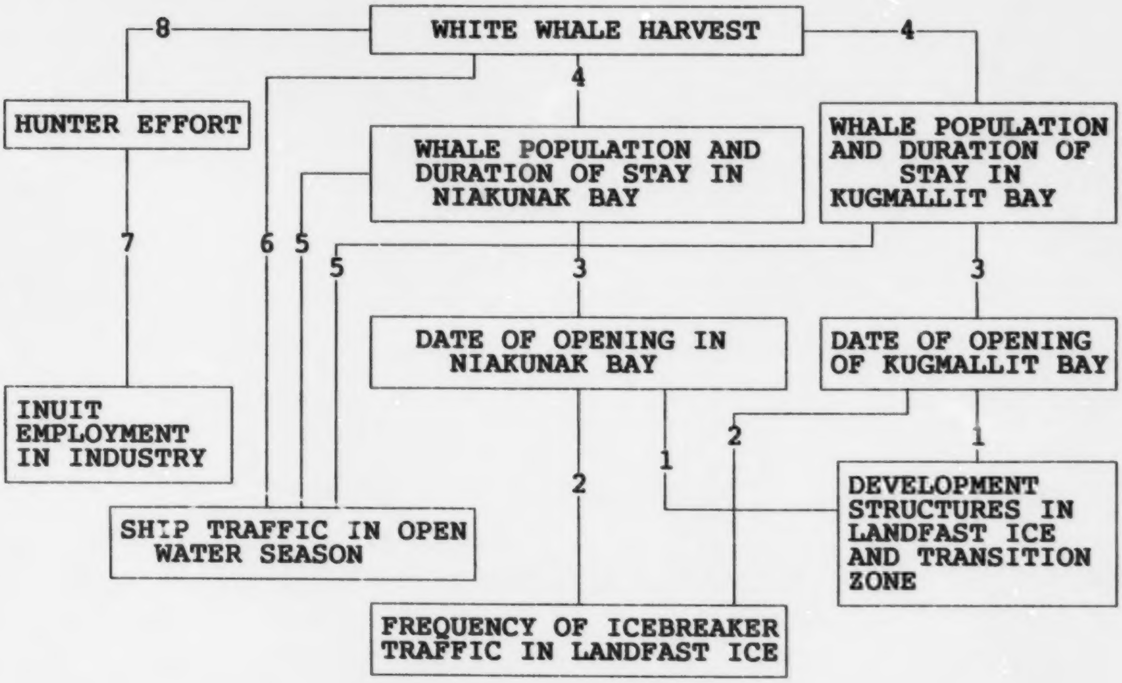
Prior to this study, doubts had been expressed about the feasibility of a study of this type, given the logistical problems and potential for interference with the spring whale hunt or other research programs. The initial 1989 phase of this study demonstrated that it is possible to conduct an experimental study of noise effects on whales migrating through leads in spring, and to do so without interfering with spring whaling.

REFERENCE

Richardson, W.J., C.R. Greene, Jr., W.R. Koski, C.I. Malme, G.W. Miller, M.A. Smultea and B. Würsig. 1990. Acoustic effects of oil production activities on bowhead and white whales during spring migration near Pt. Barrow, Alaska--1989 phase: Sound propagation and whale responses to playback of continuous drilling noise from an ice platform, as studied in pack ice conditions. Rep. from LGL Limited, King City, Ont., for U.S. Minerals Manage. Serv., Herndon, VA. 284 p.

BEMP HYPOTHESIS NO. 2

A. OFFSHORE STRUCTURES WILL REDUCE THE WHITE WHALE HARVEST
B. FREQUENT ICEBREAKER TRAFFIC IN LANDFAST ICE WILL INCREASE THE WHITE WHALE HARVEST
C. OPEN WATER SHIP TRAFFIC IN THE MACKENZIE ESTUARY WILL ALTER WHITE WHALE DISTRIBUTION AND LEAD TO CHANGES IN HARVEST LEVELS


WHITE WHALE HARVEST
8
4
4
HUNTER EFFORT
WHALE POPULATION AND DURATION OF STAY IN NIAKUNAK BAY
WHALE POPULATION AND DURATION OF STAY IN KUGMALLIT BAY
7
6
5
5
3
3
DATE OF OPENING IN NIAKUNAK BAY
DATE OF OPENING OF KUGMALLIT BAY
INUIT EMPLOYMENT IN INDUSTRY
2
1
2
1
DEVELOPMENT STRUCTURES IN LANDFAST ICE AND TRANSITION ZONE
SHIP TRAFFIC IN OPEN WATER SEASON
FREQUENCY OF ICEBREAKER TRAFFIC IN LANDFAST ICE

LINKAGES

1. Artificial islands off the Mackenzie Delta will delay the regional break-up of landfast ice.

2. Icebreaker traffic in the landfast ice in spring will advance the break-up of ice barriers across Kugmallit and Niakunak bays.

3. The timing of break-up of the landfast ice influences the timing of entry, and the numbers and the duration of residence of white whales in Niakunak and Kugmallit bays.

4. The numbers and the duration of residence of white whales in Kugmallit and Niakunak bays will influence the white whale harvest.

5. Ship passages through Niakunak and Kugmallit bays will disturb white whales, and this will reduce the number of animals that frequent the bays and/or the time that whales spend in the bays.

6. Ship traffic in Niakunak and Kugmallit bays will lead to changes in the distribution of whales in the bays, and these changes will lead to changes (probably reductions) in the harvest levels. In addition, ship traffic could directly interfere with hunting activities by frightening whales that are being hunted.

7. Increased Inuit employment by the oil industry and various supporting businesses will lead to changes in hunter effort.

8. Changes in hunter effort and experience will lead to changes in white whale harvest.

Beaufort Sea Ice: Morphology and Dynamics

BREAM PROJECT OVERVIEW NO. B2-1

PRINCIPAL INVESTIGATOR:	R. Frederking, D. Topham and H. Melling
AFFILIATION:	National Research Council, Ottawa, and Department of Fisheries and Oceans, Institute of Ocean Sciences
FUNDING SOURCE:	PERD, DFO, and NRC
EXPECTED COMPLETION DATE:	1992
RELEVANT HYPOTHESIS NO.:	BEMP 2, 3, 4, 5 and 6

BRIEF PROJECT DESCRIPTION

This project involves the coordination of several sea ice studies of the Beaufort Sea, which were initiated in 1989 and will continue until at least 1992. These studies have been conducted by personnel from several government departments including the National Research Council, the Institute of Ocean Sciences (DFO), the Bedford Institute of Oceanography, the Canada Centre for Remote Sensing, and Environment Canada. The project will provide a better understanding of complex ice geometries and internal ice properties, and the responses of sea ice to forcing on both mesoscales and larger (shelf-wide) spatial scales. One objective is to acquire a database of the thickness, draft, underside topography and motion of sea ice over the continental shelf of the southern Beaufort Sea. A wide variety of complementary data collection methods are planned. These include: (1) detailed under-ice keel profiles using long-term upward-looking sonar measurements; (2) detailed profiling of selected ice keels using a specialized ROV; (3) airborne electromagnetic sensing of sea ice thickness along selected transects as well as laser profiles of the ice ridges; (4) under-ice oceanographic distributions; (5) internal ice property measurements (i.e., ice stress, drift, thickness and temperature, and salinity profiles); and (6) aerial and satellite-based remote sensing of ice floe geometries, lead patterns and ridging distributions. In 1991/92, the European radar satellite (ERS-1) will be used to acquire synthetic aperture radar (SAR) imagery of the region.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

Results of the ice projects described above are expected to improve our understanding of sea ice processes within the region, either directly through the scientific studies being conducted or indirectly through the provision of a high quality, regional ice database. This information will be of relevance to BEMP Hypotheses Nos. 2, 3, 4, 5 and 6.

Impacts of Climatic Change on the Beaufort Sea Ice Regime

BREAM PROJECT OVERVIEW NO. B2-2

PRINCIPAL INVESTIGATOR:	D. MacGillvery
AFFILIATION:	MEP Consultants
FUNDING SOURCE:	PERD and Environment Canada
EXPECTED COMPLETION DATE:	1991
RELEVANT HYPOTHESIS NO.:	BEMP 2, 3, 4, 5 and 6

BRIEF PROJECT DESCRIPTION

The objectives of this study are to investigate possible impacts of global climate change associated with the greenhouse effect on the Beaufort Sea ice regime, and to examine the implications of changes in sea ice on the offshore oil and gas industry. Previous research using global climate models suggests that winter temperatures will increase at a much greater rate (by a factor of 2.5) than global average warming. In this study, potential changes in the southeastern Beaufort Sea will be investigated using three possible warmer climate scenarios derived from global circulation model output or empirical climate analyses. The study will estimate potential changes in ice and ocean parameters including: break-up and freeze-up dates; ice-free periods as a function of distance from shore; summer ice incursions; average thickness of first-year and multi-year ice; frequency and thickness of ice islands; and wave climatology and sea level implications due to storm surges.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study is relevant to BEMP Hypotheses Nos. 3, 4 and 5, which evaluate the effects of changes in sea ice on the size of ringed and bearded seal populations in the Beaufort Sea. The results of the study will also allow estimations of future variability of the Bathurst polynya (Hypothesis No. 6), and the break-up of ice barriers to the Mackenzie Delta in spring (Hypothesis No. 2).

A Draft Community-based Regional Land Use Plan for the Mackenzie Delta-Beaufort Sea Region

BREAM PROJECT OVERVIEW NO. B2-3

PRINCIPAL INVESTIGATOR:	Alex Aviugana
AFFILIATION:	Mackenzie Delta Beaufort Sea Regional Land Use Planning Commission
FUNDING SOURCE:	Indian and Northern Affairs Canada and Department of Renewable Resources, G.N.W.T.
EXPECTED COMPLETION DATE:	Fall 1991
RELEVANT HYPOTHESIS NO.:	BEMP 2 and 13 MEMP 23 and 24

BRIEF PROJECT DESCRIPTION

The draft plan presented in Volume 1 is the result of land use planning in the region since 1987. The planning process has involved consultation with communities, industry, governments and other interest groups in the region to identify concerns and interests in land use. The report emphasizes that because there remains a strong traditional use of renewable resources and a practice to sustain the resource, land use planning must be based on the principle that renewable resources must remain viable into the future to sustain the region's lifestyle and culture.

The draft plan for the planning region describes: the people, the natural and physical resources, an overview of present land use in the region, and management of land use. It presents a community-based framework for land use - sustainable development based on environmental conservation; general principles for land use - achieving sustainable development; direction for land use - the challenges and opportunities for sustainable development; and guidelines for land use - practising sustainable development.

The Commission lists 16 recommendations to aid in the implementation of the plan. These recommendations are designed to ameliorate conflicts that were heard during consultation in the planning process.

Volume 2 presents background information to the draft plan, including a community-by-community inventory of traditional and current resource use by community residents. It lists areas that the communities identified as requiring protection for traditional harvesting activities.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

Volume 2 serves as a database of traditional and current harvesting land use in the region. Much of the information is based on resource harvesting for domestic consumption and fur trapping export, and was derived from the traditional knowledge of the user group. The community identification of protected areas provides a written documentation and map record of human use throughout the Mackenzie Delta-Beaufort region.

The database identifies harvesting areas adjacent to Study Region communities during various seasons of the year and forms a recent documentation of the importance of those areas. These productive harvesting locations may be isolated sufficiently from the industrial activity that overall harvest levels may not be noticeably affected. The traditional knowledge presented in the report can form an important baseline for further testing of MEMP and BEMP hypotheses.

Inuvialuit Harvest Study

BREAM PROJECT OVERVIEW NO. B2-4

PRINCIPAL INVESTIGATOR:	M. Fabijan
AFFILIATION:	Joint Secretariat - Renewable Resource Committees
FUNDING SOURCE:	Fisheries Joint Management Committee, Wildlife Management Committee (North Slope & Northwest Territories), Environmental Impact Screening Committee, and Environmental Impact Review Board
EXPECTED COMPLETION DATE:	Ongoing
RELEVANT HYPOTHESIS NO.:	BEMP 2, 8 and 13 MEMP 18, 19, 21, 22, 23, 24 and 25

BRIEF PROJECT DESCRIPTION

The overall objective of the harvest study is to provide a continuous, long-term record of Inuvialuit harvests of fish and wildlife. The data will be used for fisheries and wildlife management activities, and as a basis for determining compensation in the context of industrial development in the Inuvialuit Settlement Region. Harvest data are collected on a monthly basis from all hunters in the Inuvialuit Settlement Region. The first report was scheduled for completion during the summer of 1990.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

The results of this study are relevant to some extent to all of the BEMP and MEMP hypotheses listed above. The commitment to long-term monitoring of Inuvialuit harvesting activity in the Inuvialuit Settlement Region can provide valuable baseline data from which the hypotheses may be tested and adjustments made to the management planning for the resources. The harvest data are not comprehensive for the region due to the exclusion of Dene/Metis and Inuit harvest reporting.

Environmental Atlas for Beaufort Sea Oil Spill Response

BREAM PROJECT OVERVIEW NO. B2-5

TITLE:	Environmental Atlas for Beaufort Sea Oil Spill Response
PRINCIPAL INVESTIGATOR:	D.F. Dickins[1] and L. Martin[2]
AFFILIATION:	[1]D.F.Dickins and Associates Ltd. and [2]ESL Environmental Sciences Limited
FUNDING SOURCE:	NOGAP and Environment Canada
COMPLETION DATE:	1987
RELEVANT HYPOTHESIS NO.:	BEMP 2, 8 and 13 Future impact hypotheses dealing with oil spills

BRIEF PROJECT DESCRIPTION

The environmental atlas is perhaps one of the more comprehensive undertakings in recent years in the Beaufort Sea. The atlas identifies and documents physical, biological and human use information for coastal regions and offshore in the Beaufort Seas from west of Herschel Island in the Yukon to Baillie Islands east of the Tuktoyaktuk Peninsula. The information is documented on a seasonal basis for both the onshore and offshore. Detailed information is available throughout the atlas for small sections of shoreline and the offshore.

A sensitivity ranking system was devised by the research team and applied to the combined physical, biological and human use information for each of the smaller sections of shoreline and offshore waters. The result is the identification of areas of low, moderate and high environmental sensitivity to oil spills.

The atlas also describes countermeasures that can be used in the event of an oil spill that affects each of the operational map areas.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

In relationship to BEMP Hypotheses Nos. 2, 8 and 13, the atlas presents detailed information on human use throughout the Beaufort Sea ranging from an identification of the location of camps to a description of the hunting activities and patterns by season and over the years. Although specific harvest data are not presented in the atlas, the locations of greatest use for seasonal and year-round hunting activity are identified and may form a valuable resource for future study of the relationship between harvesting and industrial activity. The atlas is also expected to be relevant to future BREAM hypotheses dealing with major oil spills.

The Canadian Oil and Gas Lands Administration, Annual Reports 1988 and 1989

BREAM PROJECT OVERVIEW NO. B2-6

PRINCIPAL INVESTIGATOR:	Anonymous
AFFILIATION:	Energy, Mines and Resources, and Indian and Northern Affairs Canada
FUNDING SOURCE:	Energy, Mines and Resources, and Indian and Northern Affairs Canada
EXPECTED COMPLETION DATE:	Annual Report
RELEVANT HYPOTHESIS NO.:	BEMP 2 MEMP 19

BRIEF PROJECT DESCRIPTION

The annual report documents employment and industrial benefits for the Mainland Territories, and Mackenzie Delta and Beaufort Sea regions in terms of total work force by the approximate number of jobs created. It further documents the total petroleum industry expenditures on frontier lands in the Mainland Territories, and Mackenzie Delta and Beaufort Sea.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

Because this is an annual publication, it is possible to develop trends in the relative number of employment opportunities in the industry. Although there is no documentation of employment opportunities to study region communities and harvesters, the database provides an indicator of the level of wage based activity, which can be useful in further testing BEMP Hypothesis No. 2 and MEMP Hypothesis No. 19.

Beluga Harvest Monitoring, 1988, 1989 and 1990

BREAM PROJECT OVERVIEW NO. B2-7

PRINCIPAL INVESTIGATOR:	Anonymous
AFFILIATION:	Unknown
FUNDING SOURCE:	Fisheries Joint Management Committee and Department Fisheries and Oceans
EXPECTED COMPLETION DATE:	Ongoing
RELEVANT HYPOTHESIS NO.:	BEMP 2 MEMP 18 and 19

BRIEF PROJECT DESCRIPTION

A traditional harvest for beluga whales is permitted each summer from the communities of Tuktoyaktuk, Inuvik and Aklavik. The Department of Fisheries and Oceans monitored the harvest between 1983 and 1986, but this responsibility was assumed by the Fisheries Joint Management Committee in 1987. Records of the number of animals struck and landed, and the sex and size of landed whales are maintained, and selected biological samples are collected annually. Analysis is undertaken by the Department of Fisheries and Oceans, while the Fisheries Joint Management Committee publishes both the harvest and biological data.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

These reports provide an ongoing standardized information base of the white whale harvest in the Mackenzie Estuary and Beaufort Sea. The information could be useful in studying the relationships of harvest to vessel traffic (BEMP Hypothesis No. 2) and harvest to wage employment (MEMP Hypotheses Nos. 18 and 19).

Responses of Migrating Narwhal and Beluga to Icebreaker Traffic at the Admiralty Inlet Ice-edge, N.W.T. in 1986

BREAM PROJECT OVERVIEW NO. B2-8

PRINCIPAL INVESTIGATORS: S.E. Cosens and L.P. Dueck
AFFILIATION: Department of Fisheries and Oceans, Freshwater Institute
FUNDING SOURCES: NOGAP
COMPLETION DATE: 1988
RELEVANT HYPOTHESIS NO: BEMP 2

BRIEF PROJECT DESCRIPTION

This study continued earlier investigations that examined the disturbance effects of ship traffic on narwhals and belugas. Four aspects of migrating narwhal and beluga behaviour were examined: relative abundance, distribution, activity and orientation. Aerial surveys of the migrating whales were conducted between 24 May and 6 July, 1986. These surveys were carried out when ships were absent from the ice edge and whales were presumed to be undisturbed, as well as when ships were in the vicinity of the ice edge.

The results of this study confirmed previous study findings that most whales avoid the ship and begin to show responses when vessels are 45 to 60 km away, suggesting that habituation may not be occurring. The results also confirmed that belugas and narwhals behave differently under normal conditions and respond differently to disturbance by ship traffic. Belugas moved farther away, and remained away from the disturbance area longer than that exhibited by narwhals. In the presence of ship traffic, belugas showed an increase in non-directed movement, a decline in directed movement and a decline in inactivity. Changes in group structure and orientation in response to ship traffic also differed between the two species.

Day-to-day variation in numbers and distribution of both species was substantial, making any assessment of the effects of ship traffic and associated noise difficult. Overall, however, the reactions of both species appeared to be less pronounced than was described in a previous study. The authors thought that this difference may be attributable to differences in ice conditions.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

Although not conducted in Beaufort Sea region, this study addresses issues of concern to BEMP Hypothesis No. 2 with respect to white whales (belugas). In particular, the findings provide important additional data to support earlier studies relating to linkages 5 and 6. While still inconclusive, the data do suggest that ship traffic in the Mackenzie Estuary is of genuine concern. Ship traffic does affect white whale behaviour.

REFERENCE

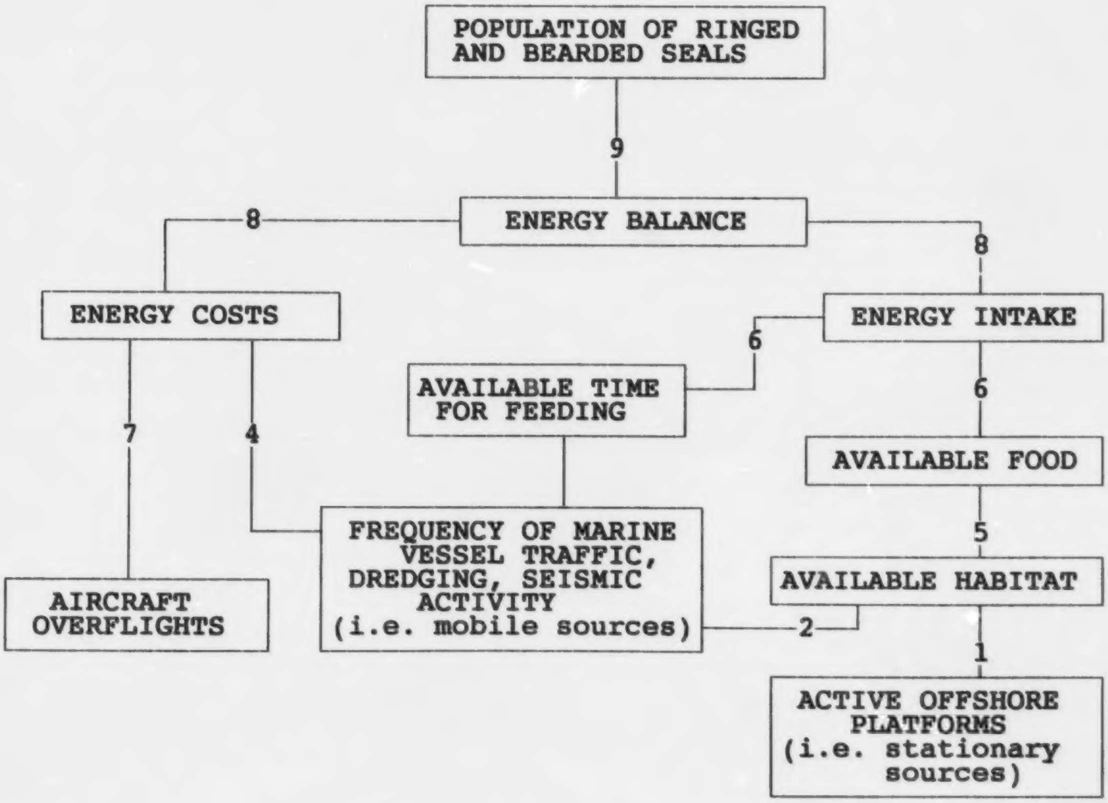
Frost, K.J. and L.F. Lowry. 1988. Effects of industrial activities on ringed seals in Alaska, as indicated by aerial surveys. Pages 15-25. *In:* W.M. Sackinger *et al*. (eds.). Port and Ocean Engineering under Arctic Conditions, Vol. II. Geophysical Institute, University of Alaska, Fairbanks, AK. 111 p.

OTHER RELEVANT PROJECTS

PROJECT	TITLE	PAGE
BEMP 1-25	Analysis and ranking of the acoustic disturbance potential of petroleum industry activities and other sources of noise in the environment of marine mammals in Alaska	126
BEMP 1-26	Effects of offshore petroleum operations on cold water marine mammals: A literature review	128
BEMP 1-27	Effects of noise on marine mammals	130
BEMP 1-29	Acoustic effects of oil production activities on bowhead and white whales visible during spring migration near Pt. Barrow, Alaska – 1989 phase: Sound propagation and whale responses to playback of continuous drilling noise from an ice platform, as studied in pack ice conditions	133

BEMP HYPOTHESIS NO. 3

MARINE VESSEL TRAFFIC, SEISMIC ACTIVITIES, DREDGING OPERATIONS AIRCRAFT OVERFLIGHTS AND ACTIVE OFFSHORE PLATFORMS/ISLANDS WILL REDUCE THE SIZE OF POPULATIONS OF RINGED AND BEARDED SEALS IN THE BEAUFORT SEA


POPULATION OF RINGED AND BEARDED SEALS
9
ENERGY BALANCE
8
8
ENERGY COSTS
ENERGY INTAKE
6
AVAILABLE TIME FOR FEEDING
6
7
4
AVAILABLE FOOD
5
FREQUENCY OF MARINE VESSEL TRAFFIC, DREDGING, SEISMIC ACTIVITY (i.e. mobile sources)
AVAILABLE HABITAT
AIRCRAFT OVERFLIGHTS
2
1
ACTIVE OFFSHORE PLATFORMS (i.e. stationary sources)

LINKAGES

1. Each active offshore platform will result in the exclusion of ringed and bearded seals from some habitat.

2. Marine traffic (ships, dredges, seismic vessels) will exclude ringed and bearded seals from available habitat.

3. Each passage of a ship or other marine vessel will reduce the feeding time available to ringed and bearded seals.

4. Each passage of a vessel will increase the energy expenditure of seals because of avoidance behaviour.

5. The available aquatic habitat can influence the level of available food.

6. The amount and quality of available food and the time available for feeding determine energy intake.

7. Noise from aircraft overflights will disturb hauled-out seals and lead to increased energy costs.

8. Energy intake and costs determine energy balance.

9. The energy balance of a seal determines its survival and its ability to reproduce. The energy balance of the individuals in a population influences the reproductive capacity and health of the population.

Effects of Industrial Activities on Ringed Seals in Alaska, as Indicated by Aerial Surveys

BREAM PROJECT OVERVIEW NO. B3-1

PRINCIPAL INVESTIGATORS:	K.J. Frost and L.F. Frost
AFFILIATION:	Alaska Department of Fish and Game
FUNDING SOURCES:	U.S. Minerals Management Service
COMPLETION DATE:	1988
RELEVANT HYPOTHESIS NO.:	BEMP 3

BRIEF PROJECT DESCRIPTION

This paper reports on the results of a 3-year (1985-87) study that monitored the ringed seal population off Alaska, and continued earlier surveys investigating the possible effects of industrial activities on ringed seals. The stable shorefast ice that is the preferred pupping habitat of ringed seals is also used as a convenient platform for some types of industrial activity. A major program of aerial surveys was conducted in this investigation, covering all of the shorefast ice along the north and northwest coasts of Alaska, to compare ringed seal abundance in "industrial" and "control" areas.

Studies around artificial islands in the central Beaufort Sea suggested that there was some displacement of seals within nautical miles of the islands. Comparisons of industrial and control blocks indicated that seals were more abundant in the industrial blocks, whether or not industrial activity had occurred. This indicated that factors other than the presence or absence of industrial activity caused the difference. There was a steady increase in the density of ringed seals in the central Beaufort Sea from 1985-87, which occurred concurrently with a decrease in industrial activity. However, in the authors' opinion the two are probably not related, since a similar increase in density was observed to occur in the western Beaufort Sea where no industrial activity took place.

The authors summarized that their studies did not show any broad-scale effect of industrial activities on ringed seal abundance and distribution in the Beaufort Sea. Nevertheless, they cautioned that these observations did not imply that such effects could not occur. They recommended that aerial surveys alone are not adequate to monitor the effects of industrial activity; they should be combined with more detailed on-ice studies.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study addresses BEMP Hypothesis No. 3, in particular linkage 1. While its findings are not conclusive, they do suggest that, perhaps, offshore drilling islands and on-ice seismic exploration do not critically affect local ringed seal abundance. The study recommendations, that aerial surveys are insufficient to answer the question and that future research should include on-ice studies, are certainly applicable to future BREAM work.

REFERENCE

Frost, K.J. and L.F. Lowry. 1988. Effects of industrial activities on ringed seals in Alaska, as indicated by aerial surveys. Pages 15-25. *In:* W.M. Sackinger *et al*. (eds.). Port and Ocean Engineering under Arctic Conditions, Vol. II. Geophysical Institute, University of Alaska, Fairbanks, AK. 111 p.

Responses of Ringed Seals (*Phoca hispida*) to Noise Disturbance

BREAM PROJECT OVERVIEW NO. B3-2

PRINCIPAL INVESTIGATORS:	B.P. Kelly, J.J. Burns and L.T. Quakenbush
AFFILIATIONS:	University of Alaska Fairbanks and Living Resources Inc. (Burns)
FUNDING SOURCES:	U.S. Minerals Management Service, North Slope Borough, and U.S. Fish & Wildlife Service
COMPLETION DATE:	1988
RELEVANT HYPOTHESIS NO.:	BEMP 3

BRIEF PROJECT DESCRIPTION

This study investigated the effects of on-ice industrial noises on ringed seals to determine the extent to which such disturbances increase the rates at which seals abandon breathing holes and lairs. The study was conducted along the Beaufort Sea coast of Alaska between 1981 and 1987, and combined on-ice surveys of seal breathing holes and lairs using trained dogs, aerial surveys of basking seals, and radiotelemetry.

In the spring of 1982, breathing holes and lairs were abandoned three times as often within 150 m of recent seismic survey lines as were structures at greater distances from the same lines. Subnivean structures (breathing holes and lairs) were abandoned at equal rates within and beyond 150 m of control lines. Aerial surveys conducted in the Beaufort Sea in 1981 and 1982, however, showed no consistent differences in the density of basking seals on transects centered over seismic survey lines and on intervening transects.

The rate of abandonment of subnivean seal structures was compared over six years. In undisturbed areas, the abandonment rate was 4.0% in shorefast ice and 12.9% in drifting ice. Among seal structures subjected to industrial noise in the shorefast ice, the rate was 13.5%, and with the addition of repeated examinations of structures by investigators the rate was 32.5%.

Radio-tagged seals departed their lairs in response to snow machines within 2.8 km, human footfalls as far away as 600 m, a skier as far away as 400 m, a helicopter flying 5 km from the lair at an altitude of 152 m, and helicopter landings or takeoffs as far away as 3 km.

Ringed seals abandon breathing holes and lairs in response to naturally occurring conditions also, such as minimal snow cover, shifting ice and the activities of predators. They abandon those sites at higher rates in response to anthropogenic noises. Seals would be most adversely affected by noise disturbance in late March through June when the amount of time they spend out of the water is increasing and movements, especially of females and their dependent young, are limited to small areas.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

The displacement of marine mammals from local areas as a result of exposure to industry noises has the potential for widespread and long-term effects. This is the focus of the present study and of BEMP Hypothesis No. 3, with respect to the ringed seal. More specifically, this study addresses Links 1, 2, 4 and 7. It provides new data that, although not conclusive, reveal that ringed seals are quite sensitive to anthropogenic noises. Whether their reactions to such noises will affect ringed seal population levels in the long-term remains to be definitively answered.

REFERENCE

Kelly, B.P., J.J. Burns and L.T. Quakenbush. 1988. Responses of ringed seals (*Phoca hispida*) to noise disturbance. Pages 27-38. *In:* W.M. Sackinger *et al.* (eds.). Port and Ocean Engineering under Arctic Conditions, Vol. II. Geophysical Institute, University of Alaska, Fairbanks, AK. 111 p.

Distribution of Ringed Seals in the Southeast Beaufort Sea during Late Summer

BREAM PROJECT OVERVIEW NO. B3-3

PRINCIPAL INVESTIGATOR:	L.A. Harwood
AFFILIATION:	University of Alberta
FUNDING SOURCES:	Canadian Departments of Indian and Northern Affairs and Fisheries and Oceans, U.S. Minerals Management Service, Dome Petroleum Ltd., Gulf Canada Resources Inc., Environmental Studies Revolving Funds, and the University of Alberta
COMPLETION DATE:	1989
RELEVANT HYPOTHESIS NO.:	BEMP 3

BRIEF PROJECT DESCRIPTION

This M.Sc. thesis investigates the distribution and relative abundance of ringed seals in the southeast Beaufort Sea. The data were gathered to examine the possible relationship between (1) the known tendency of ringed seals to occur in large, late summer and fall aggregations, and (2) extensive feeding by these seals on concentrated food organisms found in these aggregation areas. Systematic aerial surveys were conducted in August-September, 1982 and 1984-1986 to determine the distribution and abundance of seals (along with bearded seals, bowhead whales and beluga whales). Areas where ringed seals were observed to aggregate were examined with *in situ* data on zooplankton collected during an oceanographic sampling program that was conducted concurrently with aerial surveys in 1986, and with information from four ringed seals collected from the aggregation area in September 1986.

Ringed seals tended to aggregate most frequently and in greatest numbers in waters offshore of the Tuktoyaktuk Peninsula, at the approximate location where the Bathurst polynya occurs in winter. The results of the examination of aggregation areas suggested that ringed seals aggregate in late summer and fall to feed on concentrated prey found there.

The apparent relationship between fall feeding and subsequent reproductive success, first reported in the mid 1970s, could not be demonstrated in this study. Nevertheless, the results of this and concurrent studies between 1982 and 1987, together with findings that bowheads, polar bears and bearded seals were affected as well, suggested that this ecosystem is prone to large-scale fluctuations.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study provides new data fundamental to understanding the life history of the ringed seal in the Canadian Beaufort Sea. In particular, it investigates a critical feeding period in the annual cycle. Data which can contribute to understanding many of the links in BEMP Hypothesis No. 3 are presented here.

Research and management activities directed to ringed seals, and assessment of the impacts of industrial development on ringed seal populations, must recognize the large-scale fluctuations now apparent as characteristic of this ecosystem. The mechanisms which are responsible require further investigation in order to interpret the data on marine mammals being gathered in this region. They will probably have wide applicability.

REFERENCE

Harwood, L.A. 1989. Distribution of ringed seals in the southeast Beaufort Sea during late summer. M.Sc. thesis, University of Alberta, Edmonton, Alberta. 131 p.

Synthesis of Information on the Effects of Noise and Disturbance on Major Haulout Concentrations of Bering Sea Pinnipeds

BREAM PROJECT OVERVIEW NO. B3-4

PRINCIPAL INVESTIGATORS:	[1]S.R. Johnson, [2]J.J. Burns, [3]C.I. Malme and [1]R.A. Davis
AFFILIATIONS:	[1]LGL Alaska Research Associates, Inc., [2]Living Resources Inc., and [3]BBN Systems and Technologies Corporation
FUNDING SOURCE:	U.S. Minerals Management Service
COMPLETION DATE:	1989
RELEVANT HYPOTHESIS NO.:	BEMP 3, 4 and 5

BRIEF PROJECT DESCRIPTION

The purpose of this study was to provide an up-to-date and comprehensive synthesis of available information on the known and expected effects of (1) underwater noise, (2) nearby vessel traffic, (3) low-flying aircraft and (4) other associated human disturbances, on major concentrations of northern fur seals, northern sea lions, harbour seals and walruses at rookeries and haulouts in the eastern Bering Sea. Historical information on the use of each terrestrial haulout site was summarized. Available information on the effects of airborne and waterborne noise, and human disturbance (from stationary and moving sources) was reviewed. Also, a detailed analysis of the acoustic environment of eight haulout sites was conducted. These analyses included investigations of (1) airborne and underwater ambient noise, (2) industrial noise sources, and (3) sound transmission loss in air, water and through the air-water surface.

An objective, quantitative rating system was developed whereby an index of sensitivity was assigned to each site. In total, 120 of 136 identified major haulout sites were evaluated to determine their overall importance and potential vulnerability/sensitivity to human disturbances.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study provides new data that address several concerns of BREAM, although the results pertain directly to other species and to areas outside the Beaufort Sea. The results concern closely-related pinniped species and their sensitivity to human disturbances at haulout sites, and thus are indirectly applicable to BEMP Hypotheses Nos. 3, 4 and 5.

Acoustic and/or visual disturbance of animals at terrestrial haulout sites could adversely affect pupping, nursing, mating and molting, or could further decrease resistance to parasitic infection, thermoregulatory impairment, disease and other stress factors.

REFERENCE

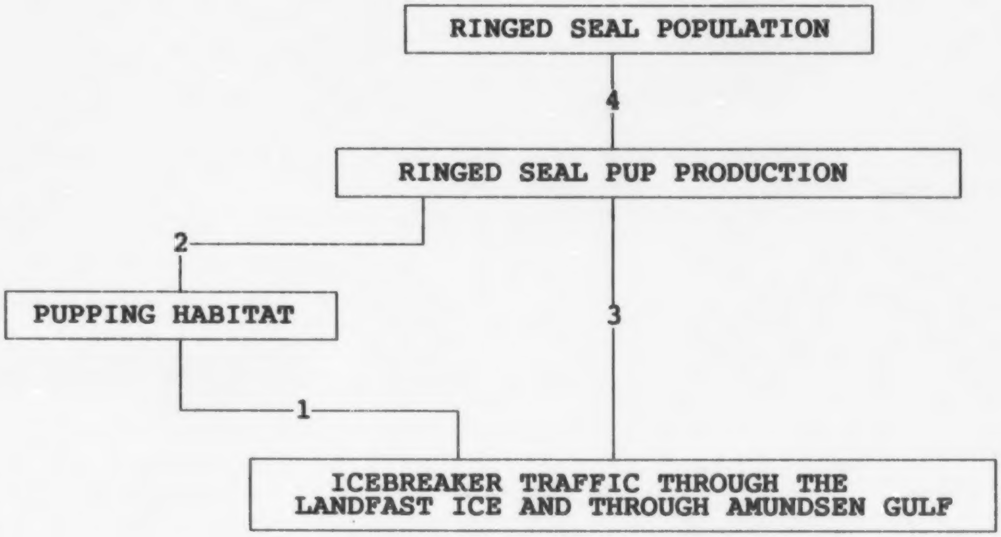
Johnson, S.R., J.J. Burns, C.I. Malme and R.A. Davis. 1989. Synthesis of information on the effects of noise and disturbance on major haulout concentrations of Bering Sea pinnipeds. OCS Study MMS 88-0092. Report from LGL Alaska Research Associates, Inc., Anchorage, Alaska for U.S. Minerals Management Service, Anchorage, Alaska. 267 p.

OTHER RELEVANT PROJECTS

PROJECT	TITLE	PAGE
BEMP 1-1	Beaufort Sea oceanography	85
BEMP 1-3	The distribution of nutrients in the southeastern Beaufort Sea: implications for water circulation and primary production	87
BEMP 1-4	Production studies in the Mackenzie River-Beaufort Sea estuary	88
BEMP 1-5	Ecological factors governing the distribution and abundance of the copepod, *Limnocalanus macrurus*, in the Beaufort Sea	90
BEMP 1-6	Zooplankton and bowhead whale feeding in the Canadian Beaufort Sea, 1986	92
BEMP 1-7	Zooplankton of a bowhead whale feeding area off the Yukon coast in August 1985	94
BEMP 1-10	Zooplankton distributions in the southeastern Beaufort Sea, summer 1987	99
BEMP 1-11	Distribution and life history of *Limnocalanus macrurus*, an estuarine copepod, in the Beaufort Sea	101
BEMP 1-25	Analysis and ranking of the acoustic disturbance potential of petroleum industry activities and other sources of noise in the environment of marine mammals in Alaska	126
BEMP 1-26	Effects of offshore petroleum operations on cold water marine mammals: A literature review	128
BEMP 1-27	Effects of noise on marine mammals	130
BEMP 2-1	Beaufort Sea ice: morphology and dynamics	137
BEMP 2-2	Impacts of climatic change on the Beaufort Sea ice regime	138

BEMP HYPOTHESIS NO. 4

INCREASED FREQUENCY OF ICEBREAKER TRAFFIC THROUGH THE LANDFAST ICE AND THROUGH AMUNDSEN GULF WILL REDUCE RINGED SEAL PUP PRODUCTION AND POPULATION LEVELS


RINGED SEAL POPULATION
4
RINGED SEAL PUP PRODUCTION
2
PUPPING HABITAT
3
1
ICEBREAKER TRAFFIC THROUGH THE LANDFAST ICE AND THROUGH AMUNDSEN GULF

LINKAGES

1. Icebreaking vessels operating in the landfast ice and through Amundsen Gulf will decrease the amount of pupping habitat available to ringed seals.

2. Adequate pupping habitat is necessary for the production of ringed seal pups.

3. Icebreaker traffic in late March, April and May will kill ringed seal pups.

4. Reduced ringed seal pup production will result in lower population levels.

Beaufort Sea Ice Motion Program

BREAM PROJECT OVERVIEW NO. B4-1

PRINCIPAL INVESTIGATOR:	H. Melling and P. Budgell
AFFILIATION:	Department of Fisheries and Oceans, Institute of Ocean Sciences
FUNDING SOURCE:	PERD and DFO
EXPECTED COMPLETION DATE:	1991
RELEVANT HYPOTHESIS NO.:	BEMP 4 and 6

BRIEF PROJECT DESCRIPTION

The overall objective of this 7-year program was to: (1) improve understanding of the interaction between sea ice and oceanic motion over the shallow shelf regions of the southeastern Beaufort Sea; and (2) formulate a better representation of oceanic effects for use in operational ice drift prediction models. The approach was two-faceted, consisting of observational studies and development of numerical ocean models.

A very extensive oceanographic database was obtained during the course of this project, including the most extensive time series measurements collected during the winter and spring to date. These data sets include: ocean current time series; salinity and temperature profile data; ice drift trajectories; seawater and sea ice chemical data; open-water drift trajectories; ice deformation and ice-field rotation time series; ice thickness profiles; meterological data; and a set of large-scale satellite imagery of sea ice and oceanographic distributions. In collaboration with Dalhousie University, water samples were collected from abyssal depths over the Arctic Ocean and analysed for chemical constituents useful in tracing the origin and age of Arctic Ocean water masses. Based on historical data that were obtained primarily during the open-water season, the interannual variability of ocean, ice and wind conditions over the past 30 years in the Beaufort Sea were also examined. The results of this analysis are available in a DFO report series (Fissel and Melling 1990, Can. Contr. Rep. Hydrogr. Ocean Sci.).

Some key findings have emerged from the multi-year observational data sets obtained during this study, which have important implications to the numerical simulation of oceanic and sea ice drift in the area. It is now clear that the predominant cause of ocean current variance at time scales exceeding one day is local forcing, rather than disturbances propagating into the area from distant sources. It is also apparent that the vertical shear and mesoscale (1 to 20 km) variability are appreciable in the summer, with strong flow features occurring on these comparatively small time and spatial scales.

A series of numerical models were developed or adapted to study ice-ocean interaction processes. Tne modelling studies, while not yet complete, suggest that the Canadian Beaufort Sea is decoupled from both the Alaska shelf region and from Amundsen Gulf in terms of barotropic dynamics. Continental shelf waves appear to be dynamically important on the Alaskan shelf, but are not significant on the Canadian Beaufort Shelf. During strong storms, ocean circulation of the Canadian Beaufort Sea is forced directly by the local wind field. In the aftermath of storms, substantial scattering of shelf waves occurs near the Mackenzie Canyon. In addition, atmospheric pressure gradients appear to generate a sizeable proportion (30 percent) of the shelf velocity fields over the outer half of the shelf, which suggests that storm systems can generate significant currents under a rigid, fully-compacted ice cover.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

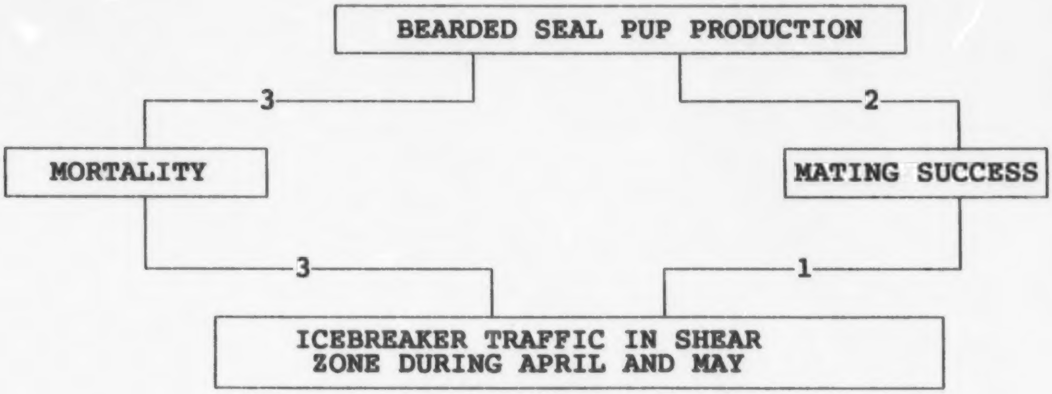
The re-supply of nutrient-rich waters to the Mackenzie shelf appears to occur primarily in autumn and winter through both regeneration of nutrients from sediments and from exchanges with the Arctic Ocean waters to the north. The availability of nutrients is one factor that determines the primary productivity and, thus, food supply to higher trophic levels. This project has provided an improved understanding of the regional circulation of the Beaufort Sea, and the combined effects of wind and topography on water and, thereby, nutrient exchanges with the adjoining areas. These results are relevant to the linkages involving primary productivity in several BEMP Hypotheses. In addition, the precisely-navigated and ice-enhanced satellite imagery will be useful in the assessing the BEMP hypothesis that deals with the effects of icebreaker traffic on ringed seal pup production (Hypothesis No. 4).

OTHER RELEVANT PROJECTS

PROJECT	TITLE	PAGE
BEMP 1-1	Beaufort Sea oceanography	85
BEMP 1-26	Effects of offshore petroleum operations on cold water marine mammals: A literature review	128
BEMP 1-27	Effects of noise on marine mammals	130
BEMP 2-1	Beaufort Sea ice: morphology and dynamics	137
BEMP 2-2	Impacts of climatic change on the Beaufort Sea ice regime	138
BEMP 3-4	Synthesis of information on the effects of noise and disturbance on major haulout concentrations of Bering Sea pinnipeds	152

BEMP HYPOTHESIS NO. 5

ICEBREAKER TRAFFIC IN THE TRANSITION (SHEAR) ZONE WILL REDUCE BEARDED SEAL PUP PRODUCTION


BEARDED SEAL PUP PRODUCTION
3
2
MORTALITY
MATING SUCCESS
3
1
ICEBREAKER TRAFFIC IN SHEAR ZONE DURING APRIL AND MAY

LINKAGES

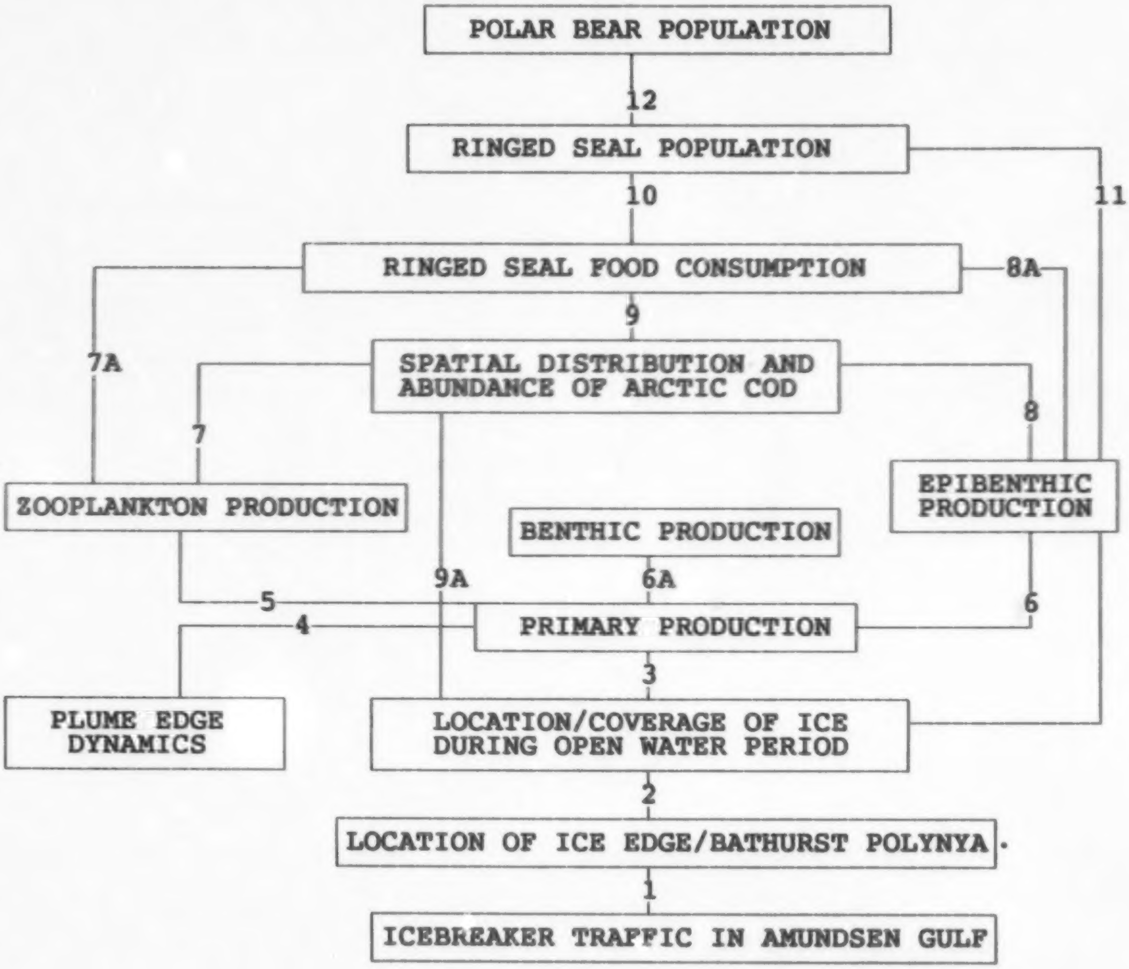
1. Icebreaker traffic in the shear zone during April and May will interfere with vocalizations of male bearded seals, and this will result in reduced mating success.
2. Successful mating is necessary for production of bearded seal pups.
3. Icebreaker traffic in the shear zone during April and May will result in mortality of bearded seal pups.

RELEVANT PROJECTS

PROJECT	TITLE	PAGE
BEMP 1-25	Analysis and ranking of the acoustic disturbance potential of petroleum industry activities and other sources of noise in the environment of marine mammals in Alaska	126
BEMP 1-26	Effects of offshore petroleum operations on cold water marine mammals: A literature review	128
BEMP 1-27	Effects of noise on marine mammals	130
BEMP 2-1	Beaufort Sea ice: morphology and dynamics	137
BEMP 2-2	Impacts of climatic change on the Beaufort Sea ice regime	138
BEMP 3-4	Synthesis of information on the effects of noise and disturbance on major haulout concentrations of Bering Sea pinnipeds	152

BEMP HYPOTHESIS NO. 6

ICEBREAKER TRAFFIC IN AMUNDSEN GULF WILL AFFECT THE RINGED SEAL AND POLAR BEAR POPULATIONS



POLAR BEAR POPULATION
12
RINGED SEAL POPULATION
10
11
RINGED SEAL FOOD CONSUMPTION
8A
9
7A
SPATIAL DISTRIBUTION AND ABUNDANCE OF ARCTIC COD
7
8
ZOOPLANKTON PRODUCTION
EPIBENTHIC PRODUCTION
BENTHIC PRODUCTION
9A
6A
5
6
4
PRIMARY PRODUCTION
3
PLUME EDGE DYNAMICS
LOCATION/COVERAGE OF ICE DURING OPEN WATER PERIOD
2
LOCATION OF ICE EDGE/BATHURST POLYNYA
1
ICEBREAKER TRAFFIC IN AMUNDSEN GULF

LINKAGES

1. Icebreaker traffic in Amundsen Gulf will move the stable ice edge to the east (and alter the Bathurst polynya) in winter and spring.

2. Movement of the stable ice edge may in turn change the total amount of open water in the region.

3. The coverage thickness and locatio of ice determine the level of primary productivity.

4. Primary production is enhanced (perhaps in patches) near the Mackenzie River plume edge.

5, 6. and 6a. The level of primary productivity determines the level of secondary productivity in zooplankton, epibenthos and benthos.

7, 8. and 9a. Distribution and production of zooplankton and epibenthos and the location of ice determine the production and distribution of arctic cod.

10. Quality and quantity of food determine ringed seal survival and mortality.

11. Location and type of ice are important in determining ringed seal distribution.

12. Numbers of polar bears are determined by numbers of ringed seals.

Arctic Cod Distribution, Abundance and Vulnerability to Perturbation

BREAM PROJECT OVERVIEW NO. B6-1

PRINCIPAL INVESTIGATOR:	R. Crawford
AFFILIATION:	Department of Fisheries and Oceans, Freshwater Institute
FUNDING SOURCE:	DFO and NOGAP
EXPECTED COMPLETION DATE:	Unknown
RELEVANT HYPOTHESIS NO.:	BEMP 6

BRIEF PROJECT DESCRIPTION

The objectives of this study are to: (1) determine the distribution and abundance of Arctic cod in various habitats during different stages of its life cycle; and (2) delimit the spawning season of Arctic cod and identify major spawning locations. Sampling effort focussed on Resolute Bay and Lancaster Sound, but also involved hydroacoustic surveys at sites outside of this area to obtain information on the abundance and distribution of Arctic cod and other fish species in the Beaufort Sea.

During the ice season, hydroacoustic surveys were conducted at sites in Resolute, Allen and Radstock bays, Barlow, Gascoyne, and Griffin inlets, Resolute Passage, Wellington Channel, McDougall Sound, Queens Channel and the mouth of Admirality Inlet. In 1987, under-ice surveys were also conducted in the nearshore zone off the Tuktoyaktuk Peninsula. Results of these surveys indicate that fish were most abundant near the landfast ice edge. During the open-water season, sampling was conducted near Cornwallis and Devon islands. Arctic cod were collected using bottom trawls and gill nets and were observed with underwater video equipment. All fish were aged and their stomach contents and sex determined. Further field work is planned for 1992-1993.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study provides basic biological information on Arctic cod population age and size structure, distribution, and abundance in the Beaufort Sea. Results will serve as background to the role of this species in determining distribution of ringed seals.

Mackenzie Shelf Fisheries Habitat Research

BREAM PROJECT OVERVIEW NO. B6-2

PRINCIPAL INVESTIGATOR:	M. Bergmann
AFFILIATION:	Department of Fisheries and Oceans, Freshwater Institute
FUNDING SOURCES:	DFO and NOGAP
EXPECTED COMPLETION DATE:	Unknown
RELEVANT HYPOTHESIS NO.:	BEMP 6, 19, and of general interest

BRIEF PROJECT DESCRIPTION

The major objectives of this investigation are to: (1) identify, in both spatial and temporal terms, the areas of the Mackenzie shelf from Demarcation Point to Cape Bathurst that are of significance to estuarine and marine fish; (2) characterize areas of important or critical marine habitats in terms of their physical-chemical environment, biotic community structure or production; and (3) describe the feeding habits of selected pelagic and demersal fish of the Mackenzie Shelf in relation to habitat and season (open water vs. ice cover).

In 1986, biological and oceanographic sampling was conducted at 71 locations on the Mackenzie Shelf from May to September. Gillnets were used to sample fish under the ice, while bottom trawls were employed during the open-water period. Oceanographic sampling was conducted from Herschel Island to Cape Bathurst from July to September. Horizontal and oblique tows with 500 μm mesh gear were used to sample larval fish, zooplankton and neuston, while vertical tows with a 83 μm mesh net were conducted to determine the abundance of larval fish food. Distribution and abundance data for major species are being compiled and mapped in relation to oceanographic parameters (depth, temperature, salinity, nutrients, and chlorophyll). In addition, NOAA-6 satellite imagery is being assessed to determine the relationship of sea surface colour and thermal attributes to biomass of selected species.

In 1987, mid-water trawls were also undertaken at various locations on the Mackenzie estuary and shelf. Results indicated that there was a significant abundance of juvenile Arctic cod in these areas. During this field year, increased emphasis was also placed on examining the biomass and distribution of ice algae as it relates to several abiotic factors such as salinity, ice clarity and snow depth. Primary productivity studies initiated in 1986 were continued during the latter half of July and August. Further investigation of ice algae was carried out during the March 1988 field program, which was expanded to include snow-ice habitat types associated with the ongoing nearshore benthic monitoring program (NOGAP Subproject B.2.3).

The field component of this study is complete and data reports are being prepared at the present time.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

The results of this study will provide basic descriptive information on biological communities of the Mackenzie Shelf and will contribute to an increased understanding of energy flow in the Beaufort Sea and the trophic relationships among components of the ecosystem.

The study is relevant to Links 7, 8 and 9a of BEMP Hypothesis No. 6. These links suggest that a reduction in the abundance of zooplankton and epibenthos will result in reduced numbers and size of cod, and that this in turn will reduce the population size of ringed seals.

This study may also provide insight into trophic relationships relevant to BEMP Hypothesis No. 19, "dredging and deposition of spoil will reduce the bearded seal population". This could presumably occur indirectly as a result of dredging-related reductions in benthic prey of bearded seals.

Workshop on Measures to Assess and Mitigate the Adverse Effects of Arctic Oil and Gas Activities on Polar Bears

BREAM PROJECT OVERVIEW NO. B6-3

PRINCIPAL INVESTIGATOR:	Jack W. Lentfer (workshop convener)
AFFILIATION:	Independent Consultant
FUNDING SOURCE:	U.S. Marine Mammal Commission
COMPLETION DATE:	1990
RELEVANT HYPOTHESIS NO.:	BEMP 6, 7, 8, 9 and 20

BRIEF PROJECT DESCRIPTION

The objectives of this workshop were to: (1) assess ways that Arctic oil and gas development might affect polar bears and their habitat; (2) determine how possible adverse effects might be avoided or mitigated; and (3) describe research that would be required to resolve any uncertainties concerning possible effects or likely effectiveness of mitigation measures. The workshop participants concluded that available information was not sufficient, in many cases, to accurately assess and determine how to avoid or mitigate possible direct and indirect effects of oil and gas activities. The likelihood of harmful interactions between bears and humans could be reduced by development of site-specific Polar Bear Interaction Plans. It was recommended that appropriate Federal and State agencies work with industry and Native groups to develop and implement such plans. The workshop noted that oil spills could affect bears in a number of ways and suggested that oil spill contingency and response team plans include measures to assess and minimize such effects. Research needs were identified by the workshop participants. Proposed research efforts included: additional radio telemetry and observation studies to better determine important polar bear denning areas and how bears may be affected by construction and operation of facilities nearby; and further evaluation and development of methods for detecting and deterring bears.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This workshop addressed, in general terms, all of the BEMP Hypotheses concerned with effects on polar bears. It is a good general review of the 'state of the art' at the time, including the identification of research gaps and procedures to be implemented to protect polar bears.

REFERENCE

Marine Mammal Commission. 1990. Workshop on measures to assess and mitigate the adverse effects of Arctic oil and gas activities on polar bears. 24-25 January 1989, Anchorage, AK. 39 p.

OTHER RELEVANT PROJECTS

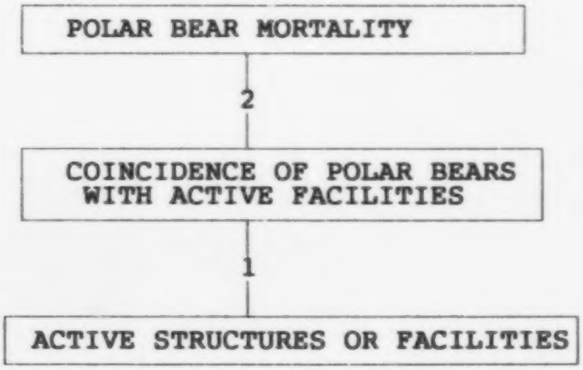
PROJECT	TITLE	PAGE
BEMP 1-1	Beaufort Sea Oceanography	85
BEMP 1-3	The distribution of nutrients in the southeastern Beaufort Sea: implications for water circulation and primary production	87
BEMP 1-4	Production studies in the Mackenzie River-Beaufort Sea estuary	88
BEMP 1-5	Ecological factors governing the distribution and abundance of the copepod, *Limnocalanus macrurus*, in the Beaufort Sea	90

OTHER RELEVANT PROJECTS (continued)

PROJECT	TITLE	PAGE
BEMP 1-6	Zooplankton and bowhead whale feeding in the Canadian Beaufort Sea, 1986	92
BEMP 1-7	Zooplankton of a bowhead whale feeding area off the Yukon coast in August 1985	94
BEMP 1-10	Zooplankton distributions in the southeastern Beaufort Sea, summer 1987	99
BEMP 1-11	Distribution and life history of *Limnocalanus macrurus*, an estuarine copepod, in the Beaufort Sea	101
BEMP 1-26	Effects of offshore petroleum operations on cold water marine mammals: A literature review	128
BEMP 1-27	Effects of noise on marine mammals	130
BEMP 2-1	Beaufort Sea ice: morphology and dynamics	137
BEMP 4-1	Beaufort Sea ice motion program	157

BEMP HYPOTHESIS NO. 7

THE PRESENCE OF ACTIVE FACILITIES WILL RESULT IN INCREASED POLAR BEAR MORTALITY


POLAR BEAR MORTALITY
2
COINCIDENCE OF POLAR BEARS WITH ACTIVE FACILITIES
1
ACTIVE STRUCTURES OR FACILITIES

LINKAGES

1. Polar bears will encounter active structures or facilities.

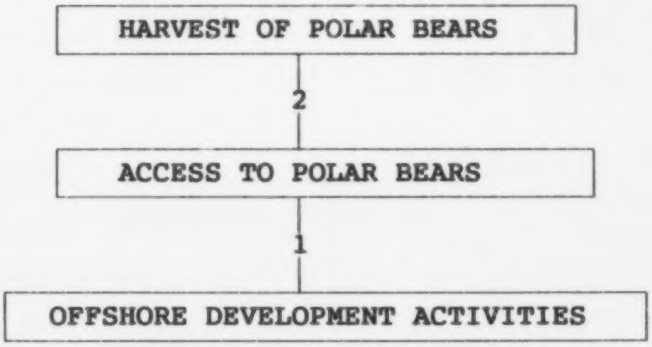
2. Polar bears that approach offshore structures have to be controlled, and this will result in the need to destroy some bears.

RELEVANT PROJECTS

PROJECT	TITLE	PAGE
BEMP 1-26	Effects of offshore petroleum operations on cold water marine mammals: A literature review	128
BEMP 1-27	Effects of noise on marine mammals	130
BEMP 6-3	Workshop on measures to assess and mitigate the adverse effects of Arctic oil and gas activities on polar bears	165

BEMP HYPOTHESIS NO. 8

OFFSHORE DEVELOPMENT ACTIVITIES WILL REDUCE THE HARVEST OF POLAR BEARS



LINKAGES

1. Hunter access to polar bears will be reduced because offshore development will cause bears to move farther offshore and/or create physical barriers to Inuit travel on the ice.

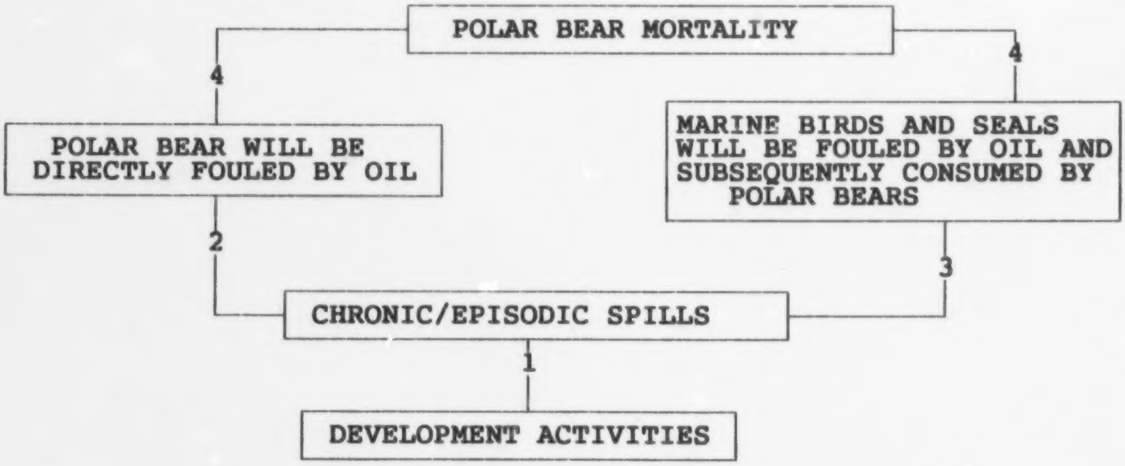
2. Reduced access to polar bears will lead to reductions in the Inuit harvest of polar bears.

RELEVANT PROJECTS

PROJECT	TITLE	PAGE
BEMP 1-26	Effects of offshore petroleum operations on cold water marine mammals	128
BEMP 1-27	Effects of noise on marine mammals	130
BEMP 2-4	Inuvialuit harvest study	140
BEMP 2-5	Environmental atlas for Beaufort Sea oil spill response	141
BEMP 6-3	Workshop on measures to assess and mitigate the adverse effects of Arctic oil and gas activities on polar bears	165

BEMP HYPOTHESIS NO. 9

CHRONIC/EPISODIC OIL SPILLS RESULTING FROM NORMAL PETROLEUM HYDROCARBON DEVELOPMENT ACTIVITIES WITHIN AND ADJACENT TO THE MARINE ENVIRONMENT WILL RESULT IN LOCALIZED MORTALITY OF POLAR BEARS


POLAR BEAR MORTALITY
4
4
POLAR BEAR WILL BE DIRECTLY FOULED BY OIL
MARINE BIRDS AND SEALS WILL BE FOULED BY OIL AND SUBSEQUENTLY CONSUMED BY POLAR BEARS
2
3
CHRONIC/EPISODIC SPILLS
1
DEVELOPMENT ACTIVITIES

LINKAGES

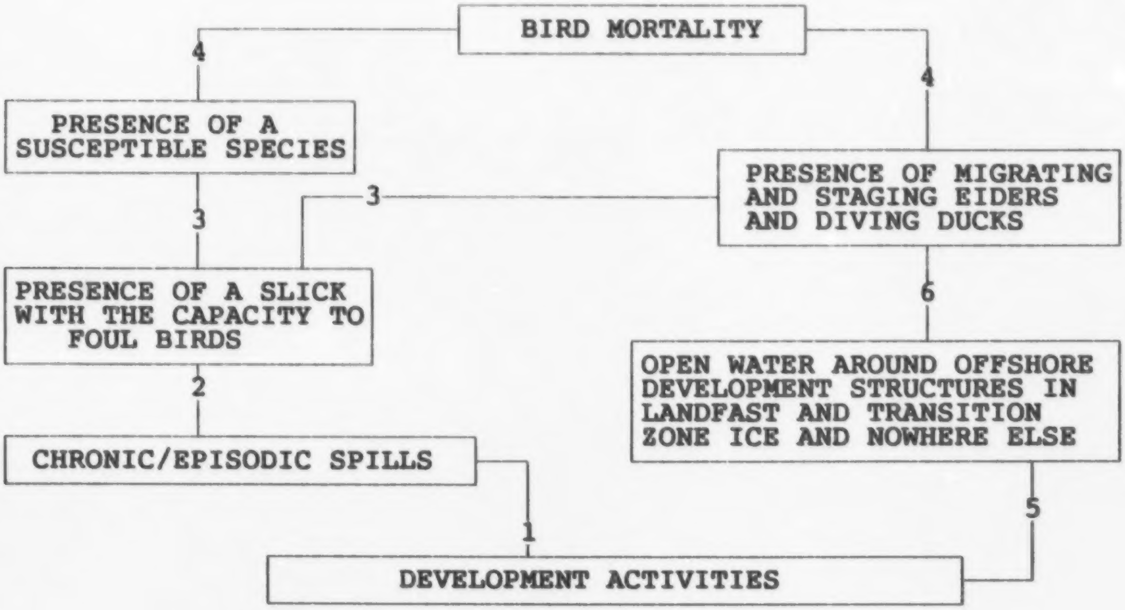
1. Development activities will result in chronic/episodic spills.
2. Chronic spills will result in the direct fouling of polar bears.
3. Chronic spills will result in the direct fouling of marine birds and seals that are consumed by bears.
4. Mortality of bears will occur if oil is contacted or ingested.

RELEVANT PROJECTS

PROJECT	TITLE	PAGE
BEMP 1-26	Effects of offshore petroleum operations on cold water marine mammals: A literature review	128
BEMP 6-3	Workshop on measures to assess and mitigate the adverse effects of Arctic oil and gas activities on polar bears	165

BEMP HYPOTHESIS NO. 10

CHRONIC (EPISODIC) OIL SPILLS RESULTING FROM NORMAL PETROLEUM HYDROCARBON DEVELOPMENT ACTIVITIES WITHIN AND ADJACENT TO THE MARINE ENVIRONMENT WILL RESULT IN LOCAL MORTALITY OF CERTAIN SPECIES OF BIRDS


BIRD MORTALITY
4
4
PRESENCE OF A SUSCEPTIBLE SPECIES
PRESENCE OF MIGRATING AND STAGING EIDERS AND DIVING DUCKS
3
3
PRESENCE OF A SLICK WITH THE CAPACITY TO FOUL BIRDS
6
2
OPEN WATER AROUND OFFSHORE DEVELOPMENT STRUCTURES IN LANDFAST AND TRANSITION ZONE ICE AND NOWHERE ELSE
CHRONIC/EPISODIC SPILLS
5
1
DEVELOPMENT ACTIVITIES

LINKAGES

1. Development activities will result in chronic (episodic) spills of petroleum hydrocarbons.
2. Where chronic (episodic) spills occur, slicks with the capacity to foul birds will be present under certain conditions.
3. Susceptible bird species will co-occur in space and time with the presence of a slick.
4. Mortality of birds will occur following slick contact.
5. Thermal discharges under or onto the ice from offshore production facilities will enhance melting and formation of open water around structures (Hypothesis No. 11, Link 3, 1983-84 BEMP report).
6. Eiders and other diving ducks are attracted to open water areas during migration and staging (Hypothesis No. 11, Link 4, 1983-84 BEMP report).

Nearshore Sediment Transport and Dynamics

BREAM PROJECT OVERVIEW NO. B10-1

PRINCIPAL INVESTIGATORS:	S. Blasco, D. Forbes, R. Taylor, S. Dalmar and P. Hill
AFFILIATION:	Atlantic Geoscience Centre, Geological Survey of Canada
FUNDING SOURCE:	NOGAP, PERD, and Oil Industry
EXPECTED COMPLETION DATE:	Various (to 1992)
RELEVANT HYPOTHESIS NO.:	BEMP 10, 13 and 20

BRIEF PROJECT DESCRIPTION

Between 1984 and 1988, a series of scientific studies were managed and conducted in the Beaufort Sea by the Atlantic Geoscience Centre (AGC), Bedford Institute of Oceanography as part of the NOGAP Beaufort Sea Coastal Zone Geotechnics, Project D.1. More recently (1989 and 1990), a number of additional studies have been carried out. The overall purpose of this project is to obtain geological data to address issues related to coastal stability, sediment transport and foundation conditions in terms of potential oil and gas development projects in the coastal zone.

Data obtained during the earlier NOGAP studies are in the final stages of analysis and scientific results are being published. Notable advances were made in the area of sediment transport and dynamics over the nearshore and shelf areas of the southeastern Beaufort Sea during summer, open-water conditions. An initial examination of sediment transport mechanisms during the period of fast-ice cover and subsequent break-up was conducted in the spring of 1987. In addition, improved understanding of the sediment dynamics in the nearshore and beach areas has emerged from the analyses of detailed sediment and oceanographic data sets obtained in the King Point area, Yukon Territory, and in the Tibjak Point area of the Tuktoyaktuk Peninsula, N.W.T.

In the summer of 1990, further field studies were carried out in the coastal regions around North Head and Pullen Island. Emphasis was placed on developing an improved understanding of coastal retreat rates. This involved collection of a number of borehole cores along an extended transect to provide a stratigraphic framework for understanding retreat rates within recent geological times. Further field work is planned for 1991 to continue this work and to investigate the role of ice scouring on nearshore sediment distribution and transport. In addition, long-term monitoring of coastal retreat rates at Tibjak Point has been continued.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

BEMP Hypotheses Nos. 10 and 13 describe a possible mechanism for environmental effects associated with chronic oil spills and releases of hydrocarbons and heavy metals from shorebases and shallow-water production facilities. The studies described in this overview will provide information regarding the possible fate and dispersal of released oil and other contaminants along the Beaufort Sea coast. In addition, the results of these studies will also provide information on background levels of naturally-occurring hydrocarbons in the vicinity of anthropogenic sources of hydrocarbons (BEMP Hypothesis No. 20).

Immediate Impact of the EXXON VALDEZ Oil Spill on Marine Birds

BREAM PROJECT OVERVIEW NO. B10-2

PRINCIPAL INVESTIGATORS:	J.F. Piatt, C.J. Lensink, W. Butler, M. Kendziorek and D.R. Nysewander
AFFILIATIONS:	Alaska Fish and Wildlife Service, Alaskan Department of Environmental Conservation, and Alaska Maritime National Wildlife Refuge
FUNDING SOURCE:	Unknown
COMPLETION DATE:	1989
RELEVANT HYPOTHESIS NO.:	BEMP 10 MEMP 10 Future impact hypotheses dealing with oil spills

BRIEF PROJECT DESCRIPTION

The objective of this investigation was to describe the movement and distribution of oil following the EXXON VALDEZ spill, the marine birds at risk and the number and species composition of dead birds retrieved from the affected area. Based on the results of aerial and ship-based surveys for populations at risk and extrapolating from the number of dead birds recovered, the total number of birds killed as a result of the oil spill was estimated.

Oil spilled from the tanker EXXON VALDEZ on 24 March, 1989, eventually drifted over 30,000 km^2 of coastal and offshore waters occupied by approximately one million marine birds. Between 25 March and 1 August, about 30,000 oiled birds were retrieved from the area affected by the spill. Although some of the birds likely died of natural causes, this was considered a minimum number due to the loss of several thousand birds unaccounted for that were buried or lost during clean-up operations. Of those birds identified, murres (74%), other alcids (7.0%) and sea ducks (5.3%) suffered the highest mortality. Between 1 August and 13 October, approximately 7000 dead birds were found; most of these were surface-feeding species that apparently died of starvation.

The number of dead oiled birds retrieved after the spill accounted for only a small portion of the actual total losses. Taking into the consideration the fact that a large number of birds killed at sea never reach shore and those that do may be overlooked, buried or scavenged before discovery, it was estimated that the actual mortality of marine birds was probably between 100,000 and 300,000.

While the immediate effect of the oil spill was to reduce the size of some local breeding populations in 1989, which will diminish production and recruitment in the future, ingestion of oil and contamination of nesting sites may reduce breeding success of those birds that survived oiling. Long-term effects of the EXXON VALDEZ spill on marine birds in the region are the subject of continuing investigations.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

Investigations initiated after the EXXON VALDEZ will provide information with which to develop and evaluate new impact hypotheses dealing with major spills and well blowouts in the Beaufort Sea. They will provide new and practical data on oil spill behaviour, cleanup, biodegradation and impacts on shoreline ecosystems; much of which may be relevant to chronic and catastrophic events in the Beaufort region. These potential events result in high degree of public concern and were clearly central issues in recent Environmental Impact Review Board (EIRB) public reviews conducted for Isserk (Esso) and Kulluk (Gulf) drilling proposals.

This particular study is of relevance to MEMP and BEMP Hypothesis No. 10, which describes the possible effects of chronic (episodic) oil spills on staging, moulting and nesting populations of waterfowl. This study, in that it describes in detail the effects of a catastrophic oil spill on arctic populations of birds, is highly relevant to the links of these hypotheses that relate to mortality of diving birds present in the area at the time of a spill.

Banks Island Bird Sanctuary No. 1. Management Plan

BREAM PROJECT OVERVIEW NO. B10-3

PRINCIPAL INVESTIGATOR:	Unknown
AFFILIATION:	Canadian Wildlife Service
FUNDING SOURCE:	Unknown
COMPLETION DATE:	1989
RELEVANT HYPOTHESIS NO.:	BEMP 10 MEMP 7, 8 and 10

BRIEF PROJECT DESCRIPTION

This report describes the formation of a bird sanctuary in the Beaufort region, discusses management goals and objectives, and provides a relatively detailed list of the bird species (56 species, including 37 known breeding species and 4 permanent residents), their abundances and their habitats found within Banks Island Bird Sanctuary No. 1.

In addition to waterfowl, peregrine falcons may also be important in the region. However, more study is required to address this issue. The Sanctuary has been subject to oil and gas exploration, but the three wells drilled in the 1970s have been abandoned because substantial hydrocarbon reserves were not discovered.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL AND ASSESSMENT MONITORING PROJECT

MEMP Hypothesis No. 7 describes a possible mechanism for environmental effects caused by hydrocarbon developments in or near waterfowl staging, moulting or nesting areas. Because it is unlikely that further hydrocarbon development will occur in the Banks Island area, this hypothesis is not valid to waterfowl populations that occur within the Sanctuary. Similarly, MEMP Hypothesis No. 8 describes the possible effects of hydrocarbon development on raptor populations. As further hydrocarbon development is unlikely in this area, this hypothesis is not likely to be applicable to the peregrine falcon population that may be present in the Banks Island Bird Sanctuary. MEMP and BEMP Hypothesis No. 10 describes the possible effects of chronic (episodic) oil spills on staging, moulting and nesting populations of waterfowl. This study provides useful baseline information on the populations of waterfowl in the Banks Island Sanctuary.

REFERENCE

CWS. 1989. Banks Island Bird Sanctuary No. 1. Management plan. Draft Report by CWS Western and Northern Region, Northern Operations Section, Yellowknife, NWT. 27 p.

Progress Report: Surveys of Geese and Swans in the Inuvialuit Settlement Region, 1989

BREAM PROJECT OVERVIEW NO. B10-4

PRINCIPAL INVESTIGATOR:	J.E. Hines
AFFILIATION:	Canadian Wildlife Service
FUNDING SOURCE:	Unknown
COMPLETION DATE:	1989
RELEVANT HYPOTHESIS NO:	BEMP 10 MEMP 7 and 10

BRIEF PROJECT DESCRIPTION

This report attempts to estimate the sizes of local waterfowl populations to define the sustainable or allowable harvest from the Inuvialuit Settlement Region (ISR). Emphasis was placed on the populations of Greater White-fronted Geese, as well as Tundra Swans and Canada Geese. Data obtained were probably underestimates of the total populations, and it was suggested that more accurate estimations could be obtained by: (1) expanding the study area to include all of the known breeding range in the ISR; (2) improving stratification of the survey area to tighten confidence estimates; (3) developing visibility correction factors to correct for missed birds; and (4) developing criteria to differentiate between breeders and non-breeders.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL AND ASSESSMENT MONITORING PROJECT

The present study is relevant to MEMP Hypothesis No. 7 and MEMP and BEMP Hypothesis No. 10, which describe possible mechanisms for environmental effects caused by hydrocarbon developments on waterfowl. This study provides good baseline data on the populations of White-fronted Geese in the ISR region and methods for studying these populations in the event of hydrocarbon development in the area.

REFERENCE

Hines, J.E., S.E. Westover and D.G. Kay. 1990. Progress report: surveys of geese and swans in the Inuvialuit Settlement region, 1989. Report by CWS Western and Northern Region, Yellowknife, NWT. 19 p.

Segregation of Brant Geese *Branta bernicla* Wintering and Staging in Puget Sound and the Strait of Georgia

BREAM PROJECT OVERVIEW NO. B10-5

PRINCIPAL INVESTIGATOR:	A. Reed
AFFILIATION:	Canadian Wildlife Service
FUNDING SOURCE:	Unknown
COMPLETION DATE:	1988
RELEVANT HYPOTHESIS NO.:	BEMP 10 MEMP 7 and 10

BRIEF PROJECT DESCRIPTION

This paper discusses an estimation of the origins of overwintering Brant Geese populations by their appearance and banding. It appears that Low Arctic populations (which include those from the Beaufort region study area) overwinter on the east coast of Vancouver Island and in small scattered groups in Washington State. The High Arctic population overwinters almost exclusively in one area, Padilla Bay, Washington.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

MEMP Hypothesis No. 7 describes a possible mechanism for environmental effects caused by hydrocarbon developments in or near waterfowl staging, moulting or nesting areas. This study is relevant only in that effects on Beaufort populations would cause changes in the southern overwintering populations, and may affect hunting in those regions. MEMP and BEMP Hypothesis No. 10 describes the possible effects of chronic (episodic) oil spills on staging, moulting and nesting populations of waterfowl. This study is relevant only in that effects on Beaufort populations would cause changes in the southern overwintering populations, and may affect hunting in those regions.

REFERENCE

Reed, A., M.A. Davison and D.A. Kraege. 1989. Segregation of brant geese, *Branta bernicla* wintering and staging in Puget Sound and the Strait of Georgia. Wildfowl 40: 22-31.

Wildlife and Wildlife Habitat Restoration in the Event of an Oil Spill in the Beaufort Sea

BREAM PROJECT OVERVIEW NO. B10-6

PRINCIPAL INVESTIGATOR:	W.E. Cross
AFFILIATION:	LGL Limited
FUNDING SOURCE:	Beaufort Sea Steering Committee
COMPLETION DATE:	1990
RELEVANT HYPOTHESIS NO.:	BEMP 10 MEMP 10 Future impact hypotheses dealing with oil spills

BRIEF PROJECT DESCRIPTION

The Environmental Impact Review Board (EIRB), which was established under the Inuvialuit Final Agreement (IFA), reviewed two applications for exploratory drilling in the nearshore Beaufort Sea. The public phases of the reviews of Isserk I-15 in November 1989 and the Kulluk DPA in June 1990 involved, in particular, discussion of section 13: Wildlife Compensation of the IFA. The objectives of Section 13 are: (a) to prevent damage to wildlife and its habitat; and (b) if damage occurs, to restore wildlife and its habitat as far as is practical to its original state. This discussion paper, prepared for a workshop in December 1990, is designed to summarize the available literature that is relevant to the situation in the Beaufort Sea if a major oil spill were to occur. The paper includes:

(1) a review of the species at risk from a spill;
(2) a summary of the effects of oil on those species;
(3) techniques and relative merits of cleaning and treating oil-exposed wildlife;
(4) techniques and relative merits of restocking depleted populations; and
(5) techniques and relative merits of restoring wildlife habitat to its original state (after standard shoreline cleanup).

While the paper includes studies on the effects of an oil spill on marine mammals, birds, fish and habitat, this summary deals only with birds and habitat. The birds most at risk from oil were identified as loons (red-throated, Pacific, common and yellow-billed), tundra swans, geese (brant, lesser snow, greater white-fronted and Canada), ducks (especially common eider, king eider and oldsquaw, as well as greater and lesser scaup, surf, white-winged and black scoter and red-throated mergansers), shorebirds (over 20 species, including red and red-throated phalarope and possibly eskimo curlew), jaegers (pomarine, parasitic and long-tailed), gulls glaucous, black-legged kittiwake, Sabine's, ivory and Ross'), terns (arctic) and alcids (thick-billed murres and black guillemot).

Reported effects of oil on birds vary with the type of oil, species of bird, weather, time of year and duration of the spill. General categories of the effects of oil on birds include behavioural, internal and external changes. Birds that are contaminated by oil frequently die because: (1) diving and resurfacing in a spill of heavy oil causes feathers to bind to the body, hampering flight and buoyancy; (2) insulative capabilities of feathers are lost, resulting in hypothermia; and (3) toxic effects of ingestion or inhalation of the oil. Although some birds may survive these immediate effects, there may be long-term effects on condition and reproduction. Diving species of birds (loons, eiders, oldsquaws, scoters, mergansers, guillemots and murres) are considered to be the most at risk; however, other species (e.g., phalaropes, gulls and terns) can be vulnerable. The history of rescue, cleaning and rehabilitation of birds is discussed in the paper, concluding with description of the now-established guidelines set by Williams (1985). These guidelines include: (1) stabilization of the bird before washing; (2) removal of oil from feathers with detergent; (3) removal of cleaning agent from feathers; (4) restoration of waterproofing; and (5) acclimatization of the bird for release. Release rates vary with species, type of oil and speed of retrieval of birds during a spill, but the results using these guidelines have been good.

Applicability of the guidelines to the Beaufort region was demonstrated by the results from the EXXON VALDEZ incident in Prince William Sound, where, of the 36,000 birds collected (out of a probable 100,000 birds affected), only 5% were rescued alive and treated and only 2% were finally released. It is suggested that rescue and recovery efforts in the Beaufort Sea would be even less than those in the Alaska spill, because there is less logistic support available. However, this may be counterbalanced by the nature of a blow-out spill as compared with a tanker spill, because the former is slower and the birds could be rescued more quickly.

Despite the above, the official policy of the RSPCA and the RSPB is that oiled birds should be destroyed and restocking should be implemented. Although restocking has not been attempted following an oil spill, other restocking programs have included releasing captive-reared fledglings, replacing eggs of endangered species into nests of similar species, and releasing juvenile and adult birds into appropriate areas. These efforts have met with variable success and none has been attempted with arctic marine species of birds; this paper suggests that the latter would be more difficult to re-establish. Enhancement of populations can be affected by increasing available nesting habitat and by eliminating hunting of those species.

The discussion paper considers habitat restoration techniques involving rehabilitation of oiled tundra and enhancement of biodegradation of oil on the shoreline after or in conjunction with standard shoreline cleanup. These techniques include: (1) allowing the area to recover naturally; (2) reseeding or replanting native or non-native plants; (3) fertilization; (4) manual removal of lumps; (5) mechanical removal over larger areas; (6) use of bacteria and soil replacement; and (7) use of fire. Experiments on arctic tundra showed fairly rapid recovery from the effects of crude oil, with full recovery to pre-spill ground cover taking about seven years. Fertilization of vegetation after a spill in Prudhoe Bay caused re-establishment of mosses during the first growing season, and enhanced growth of surviving grasses and sedges. However, fertilization in the spill area produced no significant effects. Full recovery to the pre-spill above-ground biomass can take up to 10 years. Fertilization of the supralittoral zone of arctic and sub-arctic beaches increased oil biodegradation significantly, and improved recovery of the vegetation. Manual and mechanical cleanup apparently cause more damage than leaving oil on the tundra (thermal erosion, disposal of contaminated material, trampling, etc), especially if ice lenses or a thick active layer are present. It is suggested that only small-scale mechanical cleanup should be attempted. The success of using bacteria is not yet proven, and the use of fire on oiled tundra appears to cause more damage than oiling alone. A technique to minimize further damage to oil-affected areas while stimulating regrowth has been developed and tested. This includes: (1) pumping oil-covered water areas into reserve pits to recover the oil with mop machines; (2) applying sorbents to areas that could not be pumped; (3) using manual labour to trim the tundra close to the ground surface; (4) raking to increase aeration and mix natural vegetation and root mats; (5) reducing the number of personnel in the area to 1 or 2 people using boardwalks and ramps. This method allows for restoration of the natural environment within the first season, reduces costs and the necessity for further work, and requires little monitoring.

Enhancement of biodegradation on shorelines has been tested using fertilizers. This has met with promising results, particularly on coarser-grain sediments. After the EXXON VALDEZ spill, direct spraying of an oleophilic fertilizer on to cobble or sand/gravel beaches caused significant improvement in oil cover after 2 weeks. Slow-release fertilizers were not effective. The most promising approach to enhancing biodegradation of oil is through periodic replenishment of nutrients after the indigenous microflora have adapted to the contaminated sediments.

It is expected that restoration costs in the Beaufort Sea may be even higher than those incurred in Prince William Sound because there is a relative lack of infrastructure in the region.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL AND ASSESSMENT MONITORING PROJECT

MEMP and BEMP Hypothesis No. 10 describes the possible effects of chronic (episodic) oil spills on staging, moulting and nesting populations of waterfowl. The above report is relevant to these hypotheses in that it summarizes and integrates the results of many reports and papers, as well as personal communications from researchers whose findings have not yet been published. It indicates that an oil spill in the Beaufort region would cause high mortality to all species of waterfowl in the area. The links concerned with the presence of open water (Links 5 and 6, BEMP Hypothesis 10) are not addressed in this paper.

REFERENCE

Cross, W.E., T.L. Hillis and R.A. Davis. 1990. Wildlife and wildlife habitat restoration in the event of an oil spill in the Beaufort Sea. Discussion Paper by LGL Limited, King City, Ont. for North/South Consultants, Winnipeg, on behalf of Beaufort Sea Steering Committee, Task Group 2, Hull, Quebec. 32 p.

Spring Migration of Eiders, Oldsquaws and Glaucous Gulls along Offshore Leads of the Canadian Beaufort Sea

BREAM PROJECT OVERVIEW NO. B10-7

PRINCIPAL INVESTIGATOR:	S.A. Alexander
AFFILIATION:	Canadian Wildlife Service, Western and Northern Region
FUNDING SOURCE:	NOGAP
COMPLETION DATE:	1987
RELEVANT HYPOTHESIS NO.:	BEMP 10 MEMP 7 and 10

BRIEF PROJECT DESCRIPTION

Aerial bird surveys were conducted along offshore leads in the Canadian Beaufort Sea: two sets from Herschel Island to Cape Bathurst in early June 1986, and five sets from Herschel Island to Banks Island between late May and late June, 1987. In 1987, surveys in the Banks Island area were often incomplete for logistical reasons. The Pacific eider was the most abundant species observed, followed by the King Eider and Oldsquaw, and the Glaucous Gull. A few other species were observed, notably scoters (white-winged and surf) and Red-throated Loons. In the southern parts of the Beaufort Sea, Pacific eiders, King Eiders and Oldsquaws tended to be most abundant in offshore leads between the tip of the Tuktoyaktuk Peninsula and Cape Bathurst. This was most pronounced for Pacific Eiders. Oldsquaws tended to be more evenly distributed, and Glaucous Gulls were fairly evenly distributed except for concentrations around Cape Parry. In the Banks Island area, the King Eider was the most abundant species. Pacific Eiders were present in moderate numbers, whereas Oldsquaws and Glaucous Gulls were scarce, except for a gull concentration around southwestern Banks Island. Because of their tendency to congregate, migrating eiders and oldsquaws are particularly susceptible to natural environmental disasters (such as lead systems not forming) and to man-induced disasters (such as oil spills).

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

MEMP Hypothesis No. 7 describes a possible mechanism for environmental effects caused by hydrocarbon developments in or near waterfowl staging, moulting or nesting areas. In this hypothesis, the VEC is waterfowl that stage, moult or nest in the study area and may be affected by development activities in this area. Link 2 indicates that the presence of exploratory, processing and distribution facilities may increase disturbance to waterfowl. The study described above provides information on the abundance and distribution of many species of waterfowl in the area that could be affected by hydrocarbon developments. MEMP and BEMP Hypothesis No. 10 describes the possible effects of chronic (episodic) oil spills on waterfowl, particularly diving birds. The above study briefly speculates on the vulnerability of local populations of waterfowl and gulls to natural and man-made disasters.

REFERENCE

Alexander, S.A., D.M. Ealey and S.J. Barry. 1988. Spring migration of eiders, oldsquaws and glaucous gulls along offshore leads of the Canadian Beaufort Sea. CWS Tech. Rep. Ser. No. 56. 55 p.

The Avifauna of Toker Point, Tuktoyaktuk Peninsula, Northwest Territories, 1985-1987

BREAM PROJECT OVERVIEW NO. B10-8

PRINCIPAL INVESTIGATOR:	J. Sirois
AFFILIATION:	Canadian Wildlife Service, Western and Northern Region
FUNDING SOURCE:	NOGAP
COMPLETION DATE:	1987
RELEVANT HYPOTHESIS NO.:	BEMP 10 MEMP 7 and 10

BRIEF PROJECT DESCRIPTION

A study of the impact of oil development on birds in the Beaufort Sea region was initiated in 1985. Although it focussed on Red-throated Loons, data on all bird species were collected. The report summarizes over 120,000 sightings of birds of 74 species, which were recorded daily at Toker Point, NWT, from June to September 1985, 1986 and 1987. Twelve additional species were also recorded within 100 km of the study area. In July and August, hundreds of waterfowl moulted in the area and numbers of migrating waterfowl, waders and passerines peaked in the last days of August. The numbers of most species and their relative abundance fluctuated widely from year to year, and there were few unusual sightings. These wide natural variations in bird numbers make it difficult to monitor specific or negative impacts of human activities on northern bird populations. Even natural phenomena, such as that which occurred in late spring of 1986, can adversely affect local bird populations to a large extent. However, the authors concluded that many of these species of birds would be highly vulnerable to oil spills because they tend to concentrate primarily in or near the coastline. Coastal waters and interior wetlands near Toker Point attract substantial numbers of birds. However, the potential for localized impacts on birds caused by human activities is reduced by the availability of similar habitats in the region.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

MEMP Hypothesis No. 7 describes a possible mechanism for environmental effects caused by hydrocarbon developments in or near waterfowl staging, moulting or nesting areas. In this hypothesis, the VEC is waterfowl that stage, moult or nest in the study area and may be affected by development activities in this area. Link 2 indicates that the presence of exploratory, processing and distribution facilities may increase disturbance to waterfowl. The present study provides information on the abundance and distribution of many species of birds in the area that could be affected by hydrocarbon developments, but also points out that wide fluctuations in the number of birds in the area from year to year can make it difficult to distinguish man-induced changes from those which would occur naturally.

This study is also relevant to MEMP and BEMP Hypothesis No. 10, which describes the possible effects of chronic (episodic) oil spills on waterfowl, particularly diving birds. The report provides speculations on the vulnerability of local populations of waterfowl and gulls to natural and man-made disasters.

REFERENCE

Sirois, J. and L. Dickson. 1989. The avifauna of Toker Point, Tuktoyaktuk Peninsula, Northwest Territories, 1985-1987. CWS Tech. Rep. Ser. No. 57. 49 p.

Spring Migration of Eiders, Oldsquaws and Glaucous Gulls along Offshore Leads of the Canadian Beaufort Sea

BREAM PROJECT OVERVIEW NO. B10-9

PRINCIPAL INVESTIGATOR:	D.M. Ealey
AFFILIATION:	Canadian Wildlife Service, Western and Northern Region
FUNDING SOURCE:	NOGAP and CWS
COMPLETION DATE:	1987
RELEVANT HYPOTHESIS NO.:	BEMP 10 MEMP 7 and 10

BRIEF PROJECT DESCRIPTION

From 27 July to 2 September, 1987, pre-migratory and migratory bird activities were monitored in the vicinity of Nunaluk Spit, Yukon Territory as part of a broader investigation of key areas for birds in coastal regions of the Canadian Beaufort Sea. Passage rates were determined for birds flying past an observation post located on the spit, and aerial surveys were conducted along the Yukon Territory coastline. Habitat use and distribution of waterbirds and shorebirds (particularly phalaropes) were documented during these surveys. Sixty-eight species were observed during the study period. The report discusses the relative importance of the Malcolm and Firth River deltas, Nunaluk Lagoon and Nunaluk Spit to shorebirds and waterfowl in comparison with other regions of the Beaufort Sea, and describes the staging ecology of phalaropes in relation to the findings of other studies conducted along the Beaufort Sea coast.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

MEMP Hypothesis No. 7 describes a possible mechanism for environmental effects caused by hydrocarbon developments in or near waterfowl staging, moulting or nesting areas. In this hypothesis, the VEC is waterfowl that stage, moult or nest in the study area and may be affected by development activities in this area. Link 2 indicates that the presence of exploratory, processing and distribution facilities may increase disturbance to waterfowl. The study described above provides information on pre-migratory and migratory behaviour of birds off the Yukon coast, where they could be vulnerable to human activities.

MEMP and BEMP Hypothesis No. 10 examine the possible effects of chronic (episodic) oil spills on waterfowl, especially diving birds. The above study describes pre-migration and migration behaviour of many species of birds on a spit off the Yukon coast, where they would be vulnerable to oils spills on both the water surface and the beaches where they stage (even if only for a short time such as phalaropes) or nest (e.g., common eiders and red-throated loons).

REFERENCE

Ealey, D.M., S.A. Alexander and B. Croft. 1988. Fall migration and staging of phalaropes and other waterbirds in the vicinity of Nunaluk Spit, Yukon Territory: 1987. CWS Tech. Rep. Ser. No. 41. 69 p.

Progress Report on Surveys of Geese and Swans in the Inuvialuit Settlement Region, 1988

BREAM PROJECT OVERVIEW NO. B10-10

PRINCIPAL INVESTIGATOR:	R.W. Cole
AFFILIATION:	Canadian Wildlife Service, Western and Northern Region
FUNDING SOURCE:	Inuvialuit Final Agreement
COMPLETION DATE:	1988
RELEVANT HYPOTHESIS NO.:	BEMP 10 MEMP 7 and 10

BRIEF PROJECT DESCRIPTION

Preliminary surveys were flown with fixed-wing aircraft and helicopters to evaluate methods for counting white-fronted geese, tundra swans and Canada geese in northern Canada. The authors recommend exclusive use of helicopters for surveys for several reasons: (1) to standardize survey techniques; (2) because they are potentially more accurate; and (3) inexpensive helicopter support is available near the study sites.

The number of white-fronted geese counted during these surveys (6200-8200) represents a significant proportion (>3%) of the mid-continent population. Further information has been obtained in subsequent surveys (see Project Overview No. B10-4).

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study is relevant to MEMP Hypothesis No. 7 and BEMP and MEMP Hypothesis No. 10, which describe possible mechanisms for environmental effects caused by hydrocarbon development activities and chronic (episodic) oil spills in or near waterfowl staging, moulting or nesting areas. The study provides useful baseline data on the populations of white-fronts in the Inuvialuit Settlement Region and methods for studying these populations in the event of hydrocarbon development in the area.

REFERENCE

Cole, R.W. and J.E. Hines. 1989. Progress report on surveys of geese and swans in the Inuvialuit Settlement region, 1988. Wildlife Management Advisory Council (NWT) Tech. Rep. No. 6. 18 p.

International Snow Goose Neckbanding Project - Progress Report

BREAM PROJECT OVERVIEW NO. B10-11

PRINCIPAL INVESTIGATOR:	R.H. Kerbes
AFFILIATION:	Canadian Wildlife Service, Western and Northern Region
FUNDING SOURCE:	Inuvialuit Final Agreement, Polar Shelf, Canadian Wildlife Service, Alberta Fish and Wildlife Division, and Saskatchewan Wildlife Branch
COMPLETION DATE:	1988
RELEVANT HYPOTHESIS NO.:	BEMP 10 MEMP 7 and 10

BRIEF PROJECT DESCRIPTION

This report describes banding efforts (1037 adults neckbanded, 1138 adult and young leg-banded) and counts (~102,000) of Lesser Snow Geese in the Western Arctic in 1987. Comparative monitoring of migrant and wintering geese up to early March 1988 has shown that the geese use autumn staging grounds in Saskatchewan and Alberta and wintering areas primarily in central and northern California (as well as north central Mexico, S. California and New Mexico). Data collected had not been fully analysed at the time of publication. Further banding and population estimation was to proceed in the following years.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

The International Snow Goose Neckbanding Project provides good baseline data on the populations of Lesser Snow Geese in the Western Canadian Arctic region and methods for studying these populations in the event of hydrocarbon development in the area. This study is of direct relevance to MEMP Hypotheses 7 and 10 and BEMP Hypothesis 10, which describe possible mechanisms for environmental effects caused by hydrocarbon development in or near waterfowl staging, moulting and nesting areas.

REFERENCE

Kerbes, R.H. 1988. International snow goose neckbanding project - progress report. Wildlife Management Advisory Council (NWT) Tech. Rep. No. 4. 10 p.

Neckbanding of Arctic Geese

BREAM PROJECT OVERVIEW NO. B10-12

PRINCIPAL INVESTIGATOR:	R.H. Kerbes
AFFILIATION:	Canadian Wildlife Service, Western and Northern Region
FUNDING SOURCE:	Inuvialuit Final Agreement, Polar Shelf, Canadian Wildlife Service, Alberta Fish and Wildlife Division, and Saskatchewan Wildlife Branch
EXPECTED COMPLETION DATE:	Ongoing
RELEVANT HYPOTHESIS NO.:	BEMP 10 MEMP 7 and 10

BRIEF PROJECT DESCRIPTION

This letter is a request for information on sightings or hunter recoveries of marked geese, which supplies the basis for data examined in another Project Overview. A table appended to the letter gives a sample of data collected at Queen Maud Gulf Lowlands of the Central Canadian Arctic.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

The International Snow Goose Neckbanding Project provides good baseline data on the populations of Lesser Snow Geese in the Western Canadian Arctic region and methods for studying these populations in the event of hydrocarbon development in the area. This study is of direct relevance to MEMP Hypotheses 7 and 10 and BEMP Hypothesis 10 which describe possible mechanisms for environmental effects caused by hydrocarbon development in or near waterfowl staging, moulting and nesting areas.

REFERENCE

Kerbes, R.H. 1990. Neckbanding of Arctic geese. Letter by CWS International Goose Banding Project, Saskatchewan. 2 p.

The Birds of the Beaufort Sea

BREAM PROJECT OVERVIEW NO. B10-13

PRINCIPAL INVESTIGATOR:	S.J. Johnson and D.R. Herter
AFFILIATION:	LGL Alaska Research Associates, Inc.
FUNDING SOURCE:	BP Exploration (Alaska) Inc.
COMPLETION DATE:	1989
RELEVANT HYPOTHESIS NO.:	BEMP 10 MEMP 7 and 10

BRIEF PROJECT DESCRIPTION

This book is a revised and updated version of a 1975 document (Johnson *et al.* 1975) prepared for CWS. The book contains a brief introduction, a gazetteer of the area covered, some colour photographs of habitat and birds, and individual species descriptions of all birds that have been identified in the Beaufort Sea area. The species descriptions are in taxonomic order and contain information (depending on species) on distribution and status (densities and abundances); winter range and spring migration; breeding biology; moult migration; and fall migration. There is no index, but there is an extensive bibliography.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This book is an excellent reference to birds present in the Beaufort region and their habitat and habits, and, therefore, provides information that may be useful in evaluating the validity of MEMP Hypotheses 7 and 10 and BEMP Hypothesis 10.

REFERENCE

Johnson, S.R. and D.R. Herter. 1989. The birds of the Beaufort Sea. BP Exploration (Alaska) Inc., Anchorage, AK. 372 p.

NESTUCCA Oil Spill: Impact Assessment of Avian Populations and Habitat

BREAM PROJECT OVERVIEW NO. B10-14

PRINCIPAL INVESTIGATOR:	M.S. Rodway
AFFILIATION:	Canadian Wildlife Service, Pacific and Yukon Region
FUNDING SOURCE:	Canadian Wildlife Service
COMPLETION DATE:	1989
RELEVANT HYPOTHESIS NO.:	BEMP 10 MEMP 10 Future impact hypotheses dealing with oil spills

Several reports have been prepared by Michael Rodway of the Canadian Wildlife Service that are relevant to BREAM because they examine impacts of the NESTUCCA oil spill off the coast of Washington on 23 December 1988 on bird populations. Only the references for these reports are provided in this report, but it is recommended that they be evaluated in detail during future evaluations of BEMP Hypothesis No. 10, MEMP Hypothesis No. 10 and any new hypotheses dealing with major oil spills in the Beaufort region.

REFERENCE

Rodway, M.S., M.J.F. Lemon, J.-P.L. Savard and R. McKelvey. 1989. NESTUCCA oil spill: impact assessment of avian populations and habitat. Tech. Rep. Ser. No. 68. C.W.S., Pacific and Yukon Region, B.C. 48 p.

Distribution and Abundance of Waterbirds in Barkley Sound and the Long Beach/Tofino/Grice Bay Area in Spring 1989 following the NESTUCCA Oil Spill

BREAM PROJECT OVERVIEW NO. B10-15

PRINCIPAL INVESTIGATOR:	M.S. Rodway
AFFILIATION:	Canadian Wildlife Service, Pacific and Yukon Region
FUNDING SOURCE:	Canadian Wildlife Service
COMPLETION DATE:	1989
RELEVANT HYPOTHESES NO.:	BEMP 10 MEMP 10 Future impact hypotheses dealing with oil spills

REFERENCE

Rodway, M.S. 1989. Distribution and abundance of waterbirds in Barkley sound and the Long Beach/Tofino/Grice Bay area in spring 1989 following the NESTUCCA oil spill. Tech. Rep. Ser. No. 76. C.W.S., Pacific and Yukon Region, B.C. 60 p.

Foraging Activity of Migrating Brant at Stubbs Island in April 1989 following the NESTUCCA Oil Spill

BREAM PROJECT OVERVIEW NO. B10-16

TITLE:	Foraging activity of migrating Brant at Stubbs Island in April 1989 following the NESTUCCA oil spill
PRINCIPAL INVESTIGATOR:	M.S. Rodway
AFFILIATION:	Canadian Wildlife Service, Pacific and Yukon Region
FUNDING SOURCE:	Canadian Wildlife Service
COMPLETION DATE:	1989
RELEVANT HYPOTHESIS NO.:	BEMP 10 MEMP 10 Future impact hypotheses dealing with oil spills

REFERENCE

Rodway, M.S. 1989. Foraging activity of migrating Brant at Stubbs Island in April 1989 following the NESTUCCA oil spill. Tech. Rep. Ser. No. 77. C.W.S., Pacific and Yukon Region, B.C. 27 p.

British Columbia Seabird Colony Inventory: Report #4—Scott Islands. Census Results from 1982 to 1989 with Reference to the NESTUCCA Oil Spill

BREAM PROJECT OVERVIEW NO. B10-17

PRINCIPAL INVESTIGATOR:	M.S. Rodway
AFFILIATION:	Canadian Wildlife Service, Pacific and Yukon Region
FUNDING SOURCE:	Canadian Wildlife Service
COMPLETION DATE:	1989
RELEVANT HYPOTHESIS NO.:	BEMP 10 MEMP 10 Future impact hypotheses dealing with oil spills

REFERENCE

Rodway, M.S., M.J.F. Lemon and K.R. Summers. 1990. British Columbia seabird colony inventory: Report #4—Scott Islands. Census results from 1982 to 1989 with reference to the NESTUCCA oil spill. Tech. Rep. Ser. No. 86. C.W.S., Pacific and Yukon Region, B.C. 109 p.

Attendance Patterns, Hatching Chronology and Breeding Population of Common Murres on Triangle Island, British Columbia, following the NESTUCCA Oil Spill

BREAM PROJECT OVERVIEW NO. B10-18

PRINCIPAL INVESTIGATOR:	M.S. Rodway
AFFILIATION:	Canadian Wildlife Service, Pacific and Yukon Region
FUNDING SOURCE:	Canadian Wildlife Service
COMPLETION DATE:	1989
RELEVANT HYPOTHESIS NO.:	BEMP 10 MEMP 10 Future impact hypotheses dealing with oil spills

BRIEF PROJECT DESCRIPTION

The NESTUCCA barge was damaged and started leaking oil off Grays Harbour, Washington, on 23 December 1988. The barge was towed, still leaking, to the edge of the continental shelf; the oil travelled north and was first recorded on the B.C. coast on 31 December, 1988. The amount and type of oil spilled is not reported. The above series of reports describe the effects of the oil spill on various bird populations in the affected area, and ongoing monitoring studies on long-term effects of the spill.

To help assess the impact of the oil spill in British Columbia, the Canadian Wildlife Service:

1. inspected seabird breeding colonies and known waterbird wintering and migrating areas for the presence of oil;

2. carried out aerial surveys to locate wintering concentrations of waterbirds; and

3. quantified avian mortality related to oil.

A total of 3568 dead oiled birds were found on the west coast of Vancouver Island between 3 January and 19 April 1989. Thirty-one species were identified in a sample of 856 dead birds analysed. Common murres (42%) and Cassin's auklets (32%) were most affected. Oil was encountered on seabird breeding colony islands from south of Barkley Sound, Vancouver Island to north of Bella Bella on the northern mainland coast.

In Barkley Sound, the numbers of surf scoters and gulls aggregating at herring spawn sites in March and April 1989 were comparable to previous years; western grebes and cormorants were less abundant than in 1979. In the Long Beach/Tofino/Grice Bay area, herring did not spawn in the traditional areas and there were no concentrations of surf scoters, and fewer numbers of American widgeon, goldeneye and mallard compared with previous surveys. Migrating brant on Stubbs Island did not appear to be affected by the oil *per se*, but disturbances by raptors (64%) and boats and planes (25%) reduced the amount of time spent foraging. The report suggests that: (1) the oil spill may have had an indirect effect on the distribution of scoters and gulls; (2) the declines of waterfowl numbers were likely a continuation of the decline since the 1950s; and (3) activity associated with the spill may have contributed to the disturbance that has been implicated as the primary cause of those declines.
Studies conducted in summer 1989 on the Scott Islands indicated that all species except common murres were nesting in *larger* numbers than previously recorded. The high mortality of Cassin's auklets in the oil spill had no detectable impact on the Scott Island breeding populations, and numbers of common murres did not apparently decline but their breeding success was lower than other species. Similar studies on Triangle Island, the most important common murre breeding colony in B.C., indicated that almost all birds on the east side (17% of total) abandoned the breeding ledges early in egg-laying and, elsewhere,the ratio of breeding sites to total birds was lower than at other colonies. However, there was no direct evidence that the NESTUCCA oil spill affected the breeding populations in 1989. No dead or oiled murres were observed and there was no apparent decline in overall numbers. On both Scott Islands and Triangle Island, lack of comparative data from previous seasons precluded evaluation of the observations on common murres.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

MEMP Hypothesis No. 10 and BEMP Hypothesis No. 10 describe the possible effects of chronic (episodic) oil spills on staging, moulting or nesting colonies of waterfowl. The above series of reports describing immediate and follow-up studies on waterfowl in the area of a relatively minor oil spill off the coasts of Washington and British Columbia contain data that may be useful in evaluating probable effects of spills resulting from normal hydrocarbon development in the Beaufort region. The large known and estimated numbers of dead birds caused by the NESTUCCA spill did not apparently affect the numbers of birds counted later in breeding and feeding colonies in B.C., although comparative data were not available for some of the species and areas. This latter point emphasises the need for good baseline data on numbers, distribution and composition of bird populations, so that the effects of oil spills can be better determined.

REFERENCE

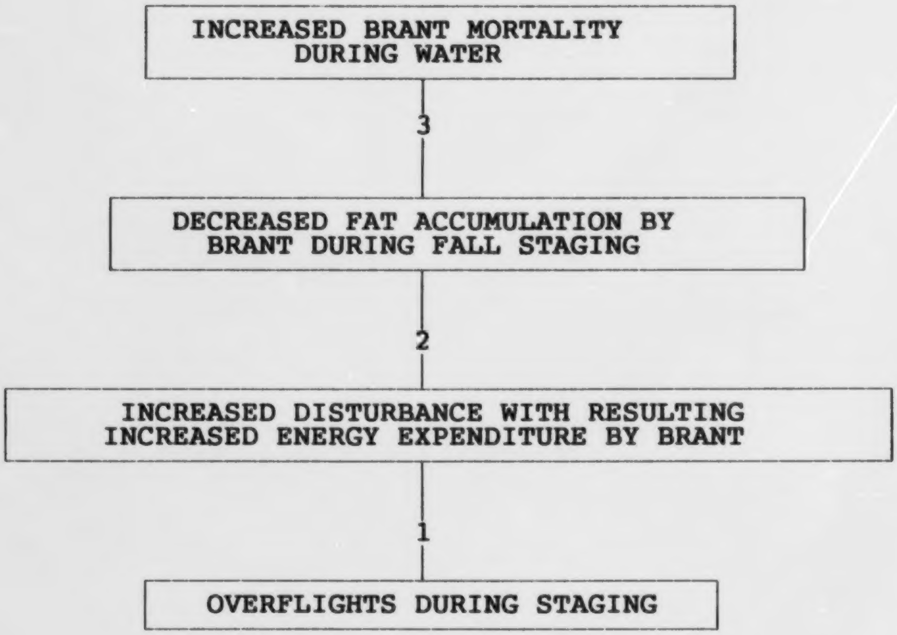
Rodway, M.S. 1990. Attendance patterns, hatching chronology and breeding population of common murres on Triangle Island, British Columbia, following the NESTUCCA oil spill. Tech. Rep. Ser. No. 87. C.W.S., Pacific and Yukon Region, B.C. 46 p.

OTHER RELEVANT PROJECTS

PROJECT	TITLE	PAGE
—	No other Project Overviews are directly relevant to BEMP Hypothesis No. 10	—

BEMP HYPOTHESIS NO. 12

FREQUENT LOW ALTITUDE AIRCRAFT FLIGHTS OVER STAGING BRANT WILL CAUSE INCREASED OVERWINTER MORTALITY


INCREASED BRANT MORTALITY DURING WATER
3
DECREASED FAT ACCUMULATION BY BRANT DURING FALL STAGING
2
INCREASED DISTURBANCE WITH RESULTING INCREASED ENERGY EXPENDITURE BY BRANT
1
OVERFLIGHTS DURING STAGING

LINKAGES

1. Aircraft overflights during spring staging of brant will cause disturbances that are reflected in increased energy expenditure.
2. Increased energy expenditure will result in decreased fat accumulation.
3. Decreased fat accumulation will increase overwinter mortality of brant.

Response of Brant and Other Geese to Aircraft Disturbances at Izembek Lagoon, Alaska

BREAM PROJECT OVERVIEW NO. B12-1

PRINCIPAL INVESTIGATOR:	D.H. Ward and R.A. Stehn
AFFILIATION:	U.S. Fish and Wildlife Service
FUNDING SOURCE:	U.S. Minerals Management Service
COMPLETION DATE:	1989
RELEVANT HYPOTHESES:	BEMP 12, MEMP 7 and 10

Effects of Aircraft on the Behaviour and Ecology of Molting Brant near Teshekpuk Lake, Alaska

BREAM PROJECT OVERVIEW NO. B12-2

PRINCIPAL INVESTIGATOR:	D.V. Derksen
AFFILIATION:	U.S. Fish and Wildlife Service
FUNDING SOURCE:	U.S. Minerals Management Service
COMPLETION DATE:	Ongoing
RELEVANT HYPOTHESES:	BEMP 12, MEMP 7 and 10

BRIEF PROJECT DESCRIPTIONS

The effects of increased aircraft disturbance and other disturbances on Pacific black brant (*Branta bernicla nigricans*) and other geese were studied at Izembek Lagoon, Alaska Peninsula, Alaska, and at Teshekpuk Lake, North Slope, Alaska. Each fall from September to

November nearly the entire Pacific Flyway population of 130,000 brant flies to Izembek Lagoon and feeds on eelgrass (*Zostera marina*) to accumulate fat reserves for non-stop transoceanic migration to wintering areas as distant as Mexico. In 1984, helicopters based in Cold Bay, Alaska, frequently flew over Izembek Lagoon to support offshore oil exploration activities in the North Aleutian Basin. These flights were observed to interrupt brant foraging behaviour. It was felt that these aircraft overflights may be harmful to brant.

Similarly, many thousands of brant from different breeding populations, but primarily from the Yukon-Kuskokwin Delta region, make an annual flight to molt in the Teshekpuk Lake Special Area (TLSA) of the National Petroleum Reserve-Alaska. The number of brant using this area in recent years has declined markedly, from a 10-year mean of nearly 20,000 birds to only about 8,000 in 1987. It was felt that aircraft overflights of molting geese may be harmful to brant in the TLSA.

Multi-year research projects were conducted in both these areas to determine the effects of aircraft overflights on brant and other geese. Neither study resulted in conclusive results indicating that brant suffered significant negative effects from aircraft overflights, but both studies indicated that the behaviour of the geese as markedly altered as a result of the overflights. At Izembek Lagoon this altered behaviour could result in a net loss of as much as 7.4 g of fat stored per aircraft overflight. An energetics model was constructed that predicted that 45-50 overflights more than normally encountered each day could conceivably affect the ability of the birds to migrate to wintering areas.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL MONITORING PROJECT

MEMP Hypothesis 7 describes the effects of disturbance associated with hydrocarbon development in or near waterfowl staging, moulting or nesting areas. MEMP Hypothesis No. 10 describes the effects of oil spills on staging and moulting waterfowl. BEMP Hypothesis No. 12 describes the effects of increased aircraft overflights associated with hydrocarbon development in or near waterfowl staging, moulting or nesting areas. The above studies, although not within the study area, involve the study of the effects of aircraft overflights on staging and molting waterfowl, primarily brant, in and around hydrocarbon developments in areas of the Bering and Beaufort seas. Such studies are valuable in assessing and monitoring the effects of developments on waterfowl.

REFERENCES

Ward, D.H, and R.A. Stehn. 1989. Response of brant and other geese to aircraft disturbance at Izembek Lagoon, Alaska. Final Report by U.S. Fish and Wildlife Service, Anchorage, AK, for U.S. Minerals Management Service, Anchorage, AK. p. 193

Derksen, D.V., K.S. Bollinger, M.R. North, D.H. Ward, M.W. Weller, K.C. Jensen, and E.J. Taylor. 1988. Effects of aircraft on the behaviour and ecology of molting brant near Teshekpuk Lake, Alaska. Progress Rep. by U.S. Fish and Wildlife Service, Anchorage, AK, for U.S. Minerals Management Service, Anchorage, AK. p. 79.

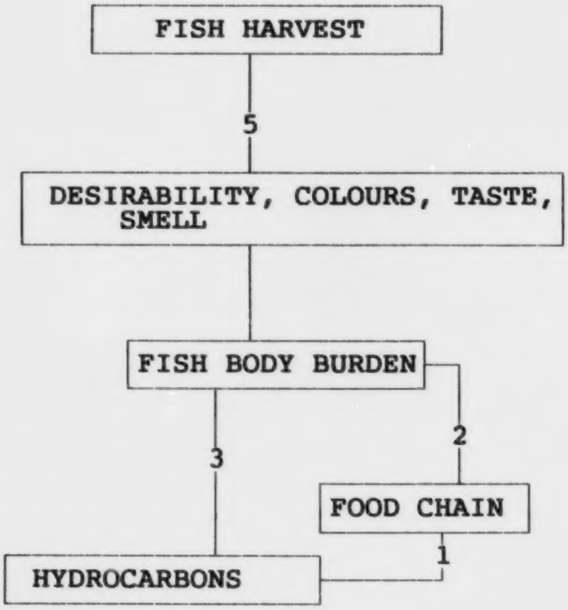
OTHER RELEVANT PROJECTS

PROJECT	TITLE	PAGE
—	No other Project Overviews are directly relevant to BEMP Hypothesis No. 12	—

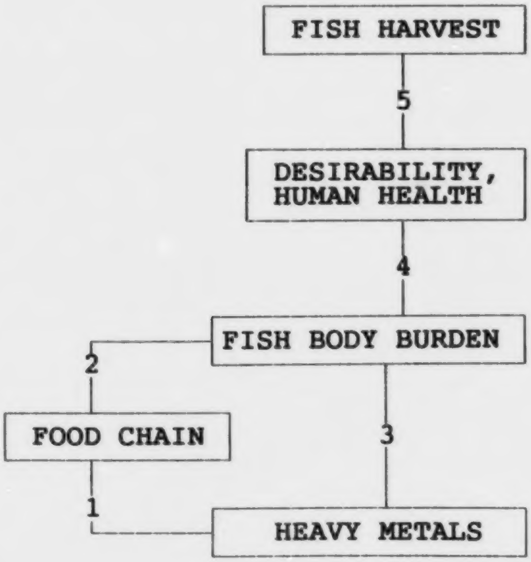
BEMP HYPOTHESIS NO. 13

SHOREBASES AND SHALLOW-WATER PRODUCTION FACILITIES WILL RELEASE HYDROCARBONS AND HEAVY METALS AT SUFFICIENT LEVELS SUCH THAT FISH HARVEST WILL BE REDUCED THROUGH TAINTING AND HEAVY METAL ACCUMULATIONS

HYPOTHESIS NO. 13A



HYPOTHESIS NO. 13B



LINKAGES FOR HYPOTHESIS 13A

1. and 3. Hydrocarbons in water and sediments will enter fish and prey organisms of harvested fish species.

2. Hydrocarbons can be passed through food chains.

4. Desirability of fish is decreased as a result of increases in body burden of hydrocarbons.

5. Decreased desirability will decrease fish harvest.

LINKAGES FOR HYPOTHESIS 13B

1. and 3. Heavy metals from water and sediments will enter fish and prey organisms of harvested fish species.

2. Heavy metals can be passed through food chains.

4. Human health and desirability of fish can be affected by increases in heavy metal concentrations.

5. Decreased desirability will decrease fish harvest.

Studies on the Condition of Fish and Hydrocarbon Exposure

BREAM PROJECT OVERVIEW NO. B13-1

PRINCIPAL INVESTIGATOR:	L. Lockhart
AFFILIATION:	Department of Fisheries and Oceans, Freshwater Institute
FUNDING SOURCE:	DFO and NOGAP
EXPECTED COMPLETION DATE:	Unknown
RELEVANT HYPOTHESIS NO.:	BEMP 13 MEMP 15

BRIEF PROJECT DESCRIPTION

A 1989 report examined whether oil pollution at Norman Wells could be responsible for the deterioration of fish quality in the Mackenzie River basin. There had been complaints that livers of burbot had become small and dark coloured and that the muscle of whitefish had become excessively "watery". Collections of burbot from several northern communities revealed that the occurrence of small dark livers was not confined to communities downstream of Norman Wells. If pollution is related to the liver condition, any pollution from Norman Wells could not be the exclusive cause. Experimental studies with burbot from Lake Winnipeg indicated that the occurrence of small, dark livers could also be induced by reducing liver fat by starvation.

Laboratory studies involving chronic exposure of trout to Norman Wells oil indicated reduced fish growth in both length and weight, and reduced weight to length ratios. Therefore, it seemed likely that fish chronically exposed to oil from Norman Wells in the early 1980s would have different body size relationships from fish taken before that time. However, a comparison of length/weight data between burbot caught in the early 1970s (by J.N. Stein) and fish caught as part of this study showed no apparent difference.

One of the most reliable indicators of oil pollution is the induction of liver microsomal oxidase enzymes. This induction was observed following the experimental treatment of burbot with Norman Wells oil in the laboratory. The most diagnostic of these enzyme activities in burbot from Fort Good Hope was not notably higher than the same activity in burbot from Lake Winnipeg. However, the presence of PCBs at higher levels in Lake Winnipeg burbot may have compromised the liver enzyme data since some congeners of PCBs also affect these enzyme activities.

Fish from Fort Good Hope and other northern communities were found to contain low levels of several low-boiling hydrocarbons that are common in the "water-soluble fraction" of Norman Wells oil. Both burbot and whitefish taken at Fort Good Hope under ice (April 1985) had much higher levels of these hydrocarbons than fish taken in open water (October 1985), suggesting that the river likely provided the source of these materials. During the open-water season, these low-boiling materials would be expected to volatilize from the water. During ice cover, these hydrocarbons would be trapped and would move downstream with the current. PAHs were also identified in some fish (identified only by retention time on high pressure liquid chromatography). Levels were generally similar or below those reported for burbot from the Finnish archipelago of the Baltic Sea. Examination of tissues indicated no unusual occurrence of metals, but unexpectedly high concentrations of several organochlorines, notably toxaphene, were found.

For the past several years, the Department of Indian Affairs and Northern Development (Yellowknife) has conducted a program to examine fish from the Slave River for signs of contaminants transported into the N.W.T. from Alberta. As part of that study, fish from the Slave River at Fort Smith are being examined for several liver biochemical responses that have been shown to occur at sites contaminated with bleached kraft pulp mill effluent or with petroleum oils. Results to date suggest that burbot and whitefish at Fort Smith are not responding to these types of contaminants. Walleye, however, may be showing a response. The significance of these findings is presently uncertain, and further research is underway.

In 1991/1992, the data base on biochemical values for whitefish in the Mackenzie Delta will also be expanded.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

The results of this study are relevant to the examination of whether the refinery operations at Norman Wells could result in a deterioration of fish quality in the Mackenzie River. Results of this study were inconclusive with respect to the source of oil-based contaminants.

REFERENCE

Lockhart, W.L., D.A. Metner, D.A.J. Murray, R.W. Danell, B.N. Billeck, C.L. Baron, D.C.G. Muir and K. Chang-Kue. 1989. Studies to determine whether the condition of fish from the lower Mackenzie River is related to hydrocarbon exposure. Environmental Studies No. 61. 84 p.

Nearshore Sediment Dynamics - Beaufort Sea

BREAM PROJECT OVERVIEW NO. B13-2

PRINCIPAL INVESTIGATORS:	D.O. Hodgins, O. Sayao, E. Kinsella and P. Morgan
AFFILIATION:	Seaconsult Marine Research Ltd.
FUNDING SOURCE:	ESRF
COMPLETION DATE:	1986
RELEVANT HYPOTHESIS NO.:	BEMP 13 and 19

BRIEF PROJECT DESCRIPTION

This study documents wave and current processes and their effect on nearshore sediment dynamics in the Beaufort Sea. Two instrument packages were deployed in the North Head area to document: (1) the progression of waves across the shelf (5m to 10m); (2) associated suspended sediment movement; and (3) pore-water pressures below the seabed as an indication of liquefaction potential.

Key findings of this study are as follows.

(1) Two majors storms were documented during the deployment with wave heights exceeding 2m (peak periods 8 to 9 s).

(2) Wave heights were reduced as the waves propagated into shallow water; an approximate 25% reduction in significant wave height occurred between the 10m and 5m stations.

(3) Surge currents associated with the waves exceeded 45cm/s at the 10m station and 78 cm/s at the 5m station.

(4) Sediment concentrations at 100cm above the seabed were elevated from background !evels of 50 to 100 mg/L to 1700 to 5800 mg/L during storms.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study is indirectly relevant to BEMP Hypotheses Nos. 13 and 19, which deal with the potential effects of release of hydrocarbons and heavy metals on fish harvest, and of dredging and deposition of spoils on bearded seal populations. In the case of Hypothesis No. 13, data collected as part of this study can be used in modelling of contaminant dispersion. Similarly for Hypothesis No. 19, results from the study may be used to calibrate sediment transport models that are used to predict zones of influence of dredge spoil.

REFERENCE

Hodgins, D.O., O.J. Sayao, E.D. Kinsella and P.W. Morgan. 1986. Nearshore sediment dynamics - Beaufort Sea. Environmental Studies Revolving Funds Report 054. 195 p.

Beaufort Sea Artificial Island Erosion Data

BREAM PROJECT OVERVIEW NO. B13-3

PRINCIPAL INVESTIGATOR:	R.D. Gillie
AFFILIATION:	Dobrocky Seatech Ltd.
FUNDING SOURCE:	ESRF
COMPLETION DATE:	May 1988
RELEVANT HYPOTHESIS NO.:	BEMP 13 and 19

BRIEF PROJECT DESCRIPTION

This report documents sediment dispersal following the abandonment of an artificial island. Poor weather conditions during the second of two surveys prevented repetitive surveys from being conducted from the same datum. Therefore, some data were compared to the 1984, "as-built" survey data.

The survey data indicated subaerial erosion rates on the island, and offshore bathymetry around the island immediately prior to submergence. During the second survey attempt, the island was submerged indicating erosion of over 20,000 m^3 of sediment in less than one month.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study is of indirect relevance to BEMP Hypothesis No. 13 (fish harvest reductions due to shorebase discharges of hydrocarbons and heavy metals) and Hypothesis No. 19 (dredging and deposition of spoils will reduce benthic invertebrate, fish and bearded seal populations). In the case of the Hypothesis No. 13, data collected as part of this study can be used in modelling of contaminant dispersion. Similarly for Hypothesis No. 19, results from the study may be used to calibrate sediment transport models that are used to predict zones of influence of dredge spoil impact.

REFERENCE

Gillie, R.D. 1988. Beaufort Sea artificial island erosion data. Environmental Studies Revolving Fund Report No. 96. 30 p. + appendices.

Chemical Interactions on the Beaufort Sea Shelf

BREAM PROJECT OVERVIEW NO. B13-4

PRINCIPAL INVESTIGATORS:	R. Macdonald and E. Carmack
AFFILIATION:	Department of Fisheries and Oceans, Institute of Ocean Sciences
FUNDING SOURCE:	NOGAP (B.6) and DFO
EXPECTED COMPLETION DATE:	Ongoing
RELEVANT HYPOTHESIS NO.:	BEMP 13 and 19

BRIEF PROJECT DESCRIPTION

This project has a number of components related to geochemical fluxes in the Canadian Beaufort Sea. In particular, these include an examination of hydrocarbon fluxes (Yunker *et al*. 1991), documentation of under-ice hydrography (Macdonald and Carmack 1991), and a review of chemical interactions and sediments (Macdonald and Thomas [in prep.]).

Some relevant findings of these studies are as follows.

1. Ice topography strongly controls the under-ice distribution of the Mackenzie River plume and the resulting circulation patterns. The plume is essentially confined to the landfast ice zone by offshore pressure ridges (i.e., the stamucki zone) (Macdonald and Carmack 1991).

2. The Mackenzie River is responsible for over 90% of the hydrocarbon input to the Beaufort Sea shelf, with components contributed to coastal erosion less than 10% (Yunker *et al*. 1991).

3. Geochemical fluxes to and from the seabed are exceedingly complex due to interaction between the Mackenzie River plume, sea ice interaction with both the plume and the seabed, and late summer storms. Atmospheric transport appears to be an important source of chlorinated organics to the Beaufort Sea (Macdonald and Thomas [in prep.]).

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

The results of this study are indirectly relevant to BEMP Hypothesis No. 13, which deals with the potential effects of shorebase discharges of hydrocarbons and heavy metals on fish harvest. Data collected as part of this study will be useful in modelling of contaminant dispersion and in understanding pollutant transport, particularly under landfast ice.

REFERENCES

Macdonald, R.W. and E.C. Carmack. 1991. The role of large-scale under-ice topography in separating estuary and ocean on an arctic shelf. Canadian Meteorological and Oceanographic Society, Atmosphere-Ocean 29(1): 37-53.

Macdonald, R.W. and D.J. Thomas. In Press. Chemical interactions and sediments; the Western Canadian Arctic Shelf.

Yunker, M.B., R.W. Macdonald, B.R. Fowler, W.J. Cretney, S.R. Dallimore and F. McLaughlin. 1991. Geochemistry and fluxes of hydrocarbons to the Beaufort Sea shelf: A multivariate comparison of fluvial inputs and coastal erosion of peat using principal components analysis. Geochemica et Cosmochimica Acta 55.

Beaufort Sea Oil Spill Modelling and Contingency Planning

BREAM PROJECT OVERVIEW NO. B13-5

PRINCIPAL CONTACTS:	N. Vanderkooy and R. Goodman
AFFILIATIONS:	Amoco Canada Petroleum Ltd. and Esso Resources Canada Ltd.
FUNDING SOURCE:	Beaufort Sea Oil Spill Cooperative
EXPECTED COMPLETION DATE:	1991
RELEVANT HYPOTHESIS NO.:	BEMP 13 Future impact hypotheses dealing with oil spills

BRIEF PROJECT DESCRIPTION

The Beaufort Sea Oil Spill Cooperative has developed a numerical model for predicting oil spill trajectories and weathering for the Canadian Beaufort Sea. The model can be used for (a) hindcasting using historical wind data and (b) trajectory predictions in the event of a spill using real-time weather data. The use of historical wind data for hindcasting permits some risk assessments to be conducted. The model is still undergoing refinement.

At the same time, the Cooperative is refining its shoreline response plan. By additional planning, the effectiveness of response is increased and should result in increased mitigation of shoreline impacts. For example, shoreline booming locations are precisely identified and, as a result, the potential for preventing oil reaching the lagoons is increased.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study is of direct relevance to BEMP Hypothesis No. 13, which deals with fish harvest reductions due to shorebase discharges of hydrocarbons and heavy metals. Following refinement of the model, results could be used to predict the risk associated with spills either in the offshore or at coastal locations. The risk models should result in improvement of oil spill response plans and in increased mitigation for potential impacts.

REFERENCES

Jayko, K., M.L. Spaulding, E. Howlett, W. Knauss, T. Isaji, E.L. Anderson, R. Goodman and B. McKenzie. 1991. Personal computer oil spill response model: Canadian Beaufort Sea. 1991 International Oilspill Conference, San Diego, CA. pp. 607-618.

Vanderkooy, N., E.H. Owens, M. Sartor and M. Lumpkin. 1991. The development of a Beaufort Sea shoreline cleanup response and operations manual. 1991 International Oilspill Conference, San Diego, CA. pp. 43-47.

Survey of Fish Users in Dene and Metis Communities in and near the Mackenzie River Watershed

BREAM PROJECT OVERVIEW NO. B13-6

PRINCIPAL INVESTIGATORS:	Sandra Auchterlonie[1] and Todd Sellers[2]
AFFILIATIONS:	[1]Lutra Associates and [2]The Rawson Academy of Aquatic Science
FUNDING SOURCE:	Natural Resources and Economic Development Branch, Department of Indian Affairs and Northern Development
COMPLETION DATE:	June 1990
RELEVANT HYPOTHESIS NO.:	BEMP 13 MEMP 24

BRIEF PROJECT DESCRIPTION

The study was initiated in response to concerns raised by resident domestic fishermen regarding the quality of fish caught in the Mackenzie River subsequent to the construction of the Norman Wells Pipeline (1982-1985). During pipeline construction, domestic fishermen reported catching fish with external and internal abnormalities. The safety of the traditional food supply was called into question.

The objective of this study was to assess the state of domestic fisheries, and examine the potential socio-economic impacts of the fish abnormalities. Interviews with 202 fishing households were conducted in and near the Mackenzie Valley and were based on a 148-question questionnaire. Questionnaire data were based on participant recall of the fishery over the previous eight years and was examined for general patterns and trends rather than quantitative descriptions of the fishery.

Country foods were estimated to account for an average of about two-thirds of the overall diet, while fish were estimated to account for one-third of the country food diet of the households. While consumption of fish had not changed over the past eight years for the majority of the households, one-third of the households were fishing less than they did eight years before. Two principal factors cited as reasons for reduced domestic fishing in communities were: (1) the trend since 1980 of keeping fewer dogs; and (2) the increasing importance of non-domestic activities in their daily lives, particularly since 1985.

The greatest number of households reporting "abnormal" fish were along the Mackenzie River. Despite reports of "abnormal" fish, almost all the households in communities described the overall quality of the fish caught as "good" rather than "poor". The study demonstrated that the domestic fishery plays a prominent role in the lives of domestic fishing households. Perceived "abnormalities" in fish may have had little impact on the domestic fishery. However, the quality of fish is of great concern to communities in the Mackenzie Valley.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study provides background information that is relevant to MEMP Hypothesis No. 24 and BEMP Hypothesis No. 13, which deal with the proximity of industrial activity to harvesting areas, the impact of abnormalities on the domestic fishery and the subsequent harvest of fish. It provides a valuable description of the importance of the domestic fishery during a period of intense industrial activity in the Mackenzie Valley. Further, it indicates that while abnormalities were evident to the fishing households, fish were consumed at the same rate as before industrial activity.

Geochemistry and Fluxes of Hydrocarbons to the Beaufort Sea Shelf (NOGAP B.6-1)

BREAM PROJECT OVERVIEW NO. B13-7

PRINCIPAL INVESTIGATORS: M. Yunker, R.W. Macdonald, B. Fowler, W. Cretney, S. Dallimore and F. McLaughlin
AFFILIATIONS: Institute of Ocean Sciences (DFO), Seakem Oceanography Ltd., and Geological Survey of Canada
FUNDING SOURCE: NOGAP and DFO
COMPLETION DATE: Complete
RELEVANT HYPOTHESIS NO: BEMP 13, 19 and 20
MEMP 15
Future impact hypotheses dealing with oil spills

BRIEF DESCRIPTION

This study is part of a broad-based study (Beaufort Sea Oceanography - NOGAP B.6), which is investigating the hydrocarbon geochemistry, primary productivity and oceanographic processes of the Beaufort Sea shelf.

Samples were collected in June and July, 1987, from the three major channels of the Mackenzie River Delta (East, Middle, Reindeer) for dissolved and particulate hydrocarbon analyses. Large volumes (> 200 L) were processed to achieve sufficient sensitivity. Peat samples from 11 coastal erosional sites were also analyzed.

The allochthonous inputs of hydrocarbon to the Canadian Beaufort Shelf were studied by applying principal components analysis (PCA) to the data. Application of PCA to Mackenzie River samples demonstrated a homogeneous system, from which the authors infer coupling or equilibrium between the river particulate hydrocarbons and the dissolved fraction.

Particulate (particle size > 0.7 μm) hydrocarbon flux from the Mackenzie River is by far the most important terrestrially-derived source of hydrocarbons to the Beaufort Sea. The Mackenzie River particulates have a distinct n-alkane signature, which can be used to identify the riverine influence on the hydrocarbon geochemistry of the Beaufort Sea Shelf. Based on one year's data, the flux of total alkanes is 440 ± 94 tonne/a and PAH 49 ± 8 tonne/a (uncertainties are one standard deviation of the sampling and analytical variation). The particulate flux exceeds the accompanying dissolved hydrocarbon flux by two orders of magnitude and has a strong seasonal cycle: winter contributes less than an estimate 0.6% of total annual flux. Deltaic silt from the western Mackenzie delta and the smaller amounts of detritus from coastal erosion of peat are minor hydrocarbon sources and contribute, in total, less than 10% to the budget for most alkanes. An important exception, with regard to shelf geochemistry, is the significant quantity of peat-derived higher plant ^{n}-alkanes.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This research is relevant to existing BEMP and MEMP hypotheses dealing with the fate of hydrocarbon inputs to the Beaufort Sea and Mackenzie River system, as well as future hypotheses that will examine major oil spills in the region.

REFERENCE

M. Yunker, R.W. Macdonald, B. Fowler, W. Cretney, S. Dallimore, and F. McLaughlin. 1991. Geochemistry and fluxes of hydrocarbons to the Beaufort Sea Shelf. Geochemica et Cosmochimica Acta. (1991): 55.

The Distribution of Hydrocarbons across the Beaufort Sea Shelf (NOGAP B.6-3)

BREAM PROJECT OVERVIEW NO. B13-8

PRINCIPAL INVESTIGATORS:	M. Yunker[1] and C. Hamilton[2]
AFFILIATION:	[1]Institute of Ocean Sciences (DFO) and [2]Seakem Oceanography Ltd.
FUNDING SOURCE:	NOGAP and DFO
EXPECTED COMPLETION DATE:	March 1992
RELEVANT HYPOTHESIS NO:	BEMP 13, 19 and 20 Future impact hypotheses dealing with oil spills

BRIEF PROJECT DESCRIPTION

This study is part of a broad-based study (Beaufort Sea Oceanography - NOGAP B.6), which is investigating the hydrocarbon geochemistry, primary productivity and oceanographic processes of the Beaufort Sea shelf. It is an extension of Study NOGAP B.6-1. The primary study objective is to characterize hydrocarbon concentrations in various compartments (water, particulates, plankton, sediments) across the shelf (from 10 m to out beyond the shelf break at 200 m water depth).

Samples from each compartment collected between 1987 and 1989 are presently being analyzed.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

The results of this study will provide a well-defined baseline and source identification for hydrocarbons in all compartments of the Beaufort Sea shelf (water, sediment, plankton) against which any anthropogenic inputs can be measured.

Recycling of Nutrients and Metals from Beaufort Sea Shelf Sediments (NOGAP B.6-5)

BREAM PROJECT OVERVIEW NO. B13-9

PRINCIPAL INVESTIGATORS: [1]C. Gobeil and R.W. Macdonald[2]
AFFILIATIONS: [1]Institute of Ocean Sciences (DFO) and [2]Institute Maurice Lamontagne (DFO)
FUNDING SOURCE: NOGAP and DFO
EXPECTED COMPLETION DATE: March 1992
RELEVANT HYPOTHESIS NO: BEMP 13

BRIEF PROJECT DESCRIPTION

This study is part of a broad-based study (Beaufort Sea Oceanography - NOGAP B.6), which is investigating the hydrocarbon geochemistry, primary productivity and oceanographic processes of the Beaufort Sea shelf.

Box cores have been collected at five locations on the Beaufort Sea shelf and are being analyzed to determine the flux of nutrients, Cd, and Zn from bottom sediments to Beaufort Sea Shelf waters.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

The results of this study will be relevant to BEMP Hypothesis No. 13 by further defining "natural" sources of metals and allowing estimates to be made of the potential long-term release of metals from sediments that may have been contaminated through chronic or catastrophic spill events.

The Flux of Suspended Particulates, Petroleum-related Hydrocarbons, Trace Metals and Nutrients from the Mackenzie River during the Winter Season: A Pilot Study of the East Channel

BREAM PROJECT OVERVIEW NO. B13-10

PRINCIPAL INVESTIGATORS:	P. Erickson and B. Fowler
AFFILIATION:	Arctic Laboratories Limited
FUNDING SOURCE :	Indian and Northern Affairs Canada, and Supply and Services Canada
COMPLETION DATE:	Complete
RELEVANT HYPOTHESIS NO:	BEMP 13, 19 and 20 MEMP 15 Future impact hypotheses dealing with oil spills

BRIEF PROJECT DESCRIPTION

Water and suspended particulates were collected through the ice in the East Channel of the Mackenzie River about 30 km upstream from Kittigazuit Bay in April 1985 and early February 1986 to estimate the winter dissolved and particulate fluxes of trace metals, nutrients and petroleum-related hydrocarbons to the Beaufort Sea. In February 1986, samples were also collected in the Main, Middle and Reindeer channels to compare fluxes in the other major channels.

The results indicate that the Middle, Reindeer and East channels account for all of the winter flow through the Main Channel. Suspended particulate loads decrease as a function of current speed and distance downstream. About 25% of the particulates by weight in the Main Channel settled out over a distance of about 100 km (between the Main Channel and outer channel sites). Mean concentrations were 5.15 mg L^{-1} in the East Channel in 1986 (4.78 in 1985), 4.89 mg L^{-1} in Reindeer Channel, and 4.58 mg L^{-1} in Middle Channel. Suspended particulates have a peak in size distribution between 2 and 6 µm in these channels.

Concentrations of dissolved nonpolar and aromatic hydrocarbons were below detection limits as determined by UV-fluorescence, GC/FID and GC/MS analyses. Quantifiable concentrations of nonpolar and aromatic hydrocarbons were found in particulates by bottle sample filtration and filtration during *in-situ* sampling. The particulate hydrocarbons were qualitatively very similar, although there were minor compositional differences between continuous-flow centrifuge and filtration sampling methods. A pronounced odd-carbon predominance in the higher alkanes indicated that the primary hydrocarbon source for all the particulate samples is terrestrial plant wax material.

Trace metals such as Cu, Cd, As, Hg, Pb, and V appear to be primarily in a dissolved phase, while Zn, Cr and Ni have a particulate component equal to or greater than dissolved levels. The winter river metal concentrations when compared to available Beaufort Sea data and recent data for other oceanic regions indicate that the river is a source of Cu, Ni, V, Zn, Pb and Cr. Concentrations of Cd and As are lower in the river than in shelf water, while Hg concentrations appear to be about the same.

Mean concentrations of nutrients were 9.0 mmol m^{-3} N (as nitrate); 60 mmol m^{-3} Si (as silicate and 0.08 mmol m^{-3} P (as orthophosphate). The river is, therefore, a source of Si; nitrate levels are similar to those in shelf water while phosphate concentrations in the river are at least an order of magnitude lower than marine concentrations.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

The study provides background data on nutrients, metals and petroleum-related hydrocarbons in the Mackenzie River, and the flux of these materials to the Beaufort Sea Shelf in the winter. This information is of relevance to all MEMP and BEMP hypotheses that link environmental effects to the release or increase of these potential contaminants. It is important for defining the "natural" contribution of metals and hydrocarbons to the Shelf in the winter months and hence for relating any contributions from a catastrophic spill.

REFERENCE

Erickson, P. and B. Fowler. 1987. The flux of suspended particulates, petroleum related hydrocarbon trace metals and nutrients from the Mackenzie River during the winter season: A pilot study of the East Channel. Environmental Studies No. 48, Northern Affairs Program. Department of Indian Affairs and Northern Development.

Study of the Environmental Effects of Industry Staging Activities on the Marine Environment - Year One

BREAM PROJECT OVERVIEW NO. B13-11

PRINCIPAL INVESTIGATORS: P. Erickson[1], M. Burnside[1] and D. Dickins[2]
AFFILIATION: [1]Seakem Oceanography Ltd. and [2]DF Dickins & Associates
FUNDING SOURCE: Department of Environment, Environmental Protection
COMPLETION DATE: March 1991
RELEVANT HYPOTHESIS NO: BEMP 13, 19 and 20

BRIEF PROJECT DESCRIPTION

The objective of this study is to review historic uses and major contaminants associated with industrial uses of Herschel Basin and McKinley Bay. Surface sediments were collected in the fall of 1990, which will provide an evaluation of the current status of the contaminant levels in the surficial sediments in the two staging areas. A preliminary risk assessment of the contaminants that have been or could be introduced into the marine environment of these basins will be prepared.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study will provide additional baseline and background data on contaminant levels in two nearshore coastal environments.

The Tuktoyaktuk Harbour Benthic Biological Monitoring Programme

BREAM PROJECT OVERVIEW NO. B13-12

PRINCIPAL INVESTIGATOR: D.J. Thomas
AFFILIATION: Seakem Oceanography Ltd.
FUNDING SOURCE: NOGAP
COMPLETION DATE: Complete
RELEVANT HYPOTHESIS NO: BEMP 13 and 20

BRIEF PROJECT DESCRIPTION

During 1986 and 1987, a study was conducted in Tuktoyaktuk Harbour to: (1) assess the potential lethal and sublethal effects of chronic contaminant input into the Harbour on indigenous benthic fauna; and (2) assess methods for studying lethal and sublethal effects on benthic fauna to determine which methods are suitable for wider application to program that are designed to monitor potential point source impacts associated with Beaufort Sea industrial development activities. The rationale and strategy for the monitoring program including the identification of target species and target contaminants were developed by an interdisciplinary working group knowledgeable in the physical, chemical and biological characteristics of Tuktoyaktuk Harbour.

The target contaminants were petroleum hydrocarbons (both aromatic and aliphatic fractions) and mercury. Sediments and water were collected to establish the levels of these contaminants in the Harbour.

Data from sampling Trip 1 of the Tuktoyaktuk Benthic Monitoring Program led to the following conclusions.

1. The concentrations of hydrocarbons (alkanes and polyaromatics) in Tuktoyaktuk Harbour sediments are higher than those along the Tuktoyaktuk Peninsula and offshore Beaufort Sea.
2. There is a local source of PAH in the Tuktoyaktuk Harbour area that causes the distribution of PAH compounds to be different from that typical of Mackenzie River suspended particulates.
3. The presence of MFO in the livers of starry flounder and arctic flounder indicate that both these species have been exposed to petroleum hydrocarbons. This conclusion is further supported by the presence of PAH metabolites in the bile of these fish.
4. Histopathological examinations of liver tissue indicate that while both species are under stress, the arctic flounder is in poorer health than the starry flounder, as evidenced by the greater incidence of degenerative, prenoplastic or neoplastic lesions.
5. The concentration of mercury in the flesh of both species of flounder is within the range observed previously for fish in the Beaufort Sea.
6. There are insufficient data to evaluate the possible relationship between the presence of lesions and histopathological abnormalities and (1) bile PAH concentrations, (2) presence of MFO enzyme activity and (3) concentrations of hydrocarbons in various fish tissues.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

Results of the study provide information on the long-term accumulation of contaminants in a heavily-used coastal embayment on the Beaufort Sea coast (Tuk Harbour); the possible relationship between the presence of contaminants and the health of flounder; and contaminant concentrations in the sediments of Tuk Harbour and Kugyuktuk Bay. The study also provides data on bioaccumulation of petroleum hydrocarbons in fish. An important aspect of the study is that it provides valuable information on the applicability of certain monitoring approaches in the Arctic.

MFO Induction Measurement (PERD No. 67209)

BREAM PROJECT OVERVIEW NO. B13-13

PRINCIPAL INVESTIGATORS:	R.F. Addison and J.A. Elliot
AFFILIATION:	Department of Fisheries and Oceans, Bedford Institute of Oceanography
FUNDING SOURCE:	DFO and PERD
COMPLETION DATE:	Unknown
RELEVANT HYPOTHESIS NO:	BEMP 13 and 20 MEMP 15B

BRIEF PROJECT DESCRIPTION

The objectives of this study are to: (1) demonstrate the usefulness of the MFO induction technique to monitor hydrocarbon exposure; (2) assess the potential of specific Cytochrome P-450 isozyme induction in fish and shellfish to monitor hydrocarbon exposure; and (3) carry out dose-response studies of MFO induction and gill lesion induction in pelagic fish exposed to sediment-bound oil.

Hepatic mono-oxygenase activity was examined in indigenous populations of winter flounder as an indicator of spatial changes in hydrocarbon contamination. PAH contamination from the "tar ponds" at Sydney, N.S. was used as a test contamination gradient. Winter flounder were sampled in Georges Bay, N.S. (a control site) and at three points in Sydney Harbour ascending a gradient of PAH in sediments (data from EPS). Two indices of mono-oxygenase activity were measured: ethoxyresorufin O-de-ethylase (EROD) and cyanoethoxycoumarin O-de-ethylase (CN-ECOD). PAH levels ranged from not detectable (Georges Bay) to approximately 55 nmol/g liver/min - a difference of about 3-4 fold. CN-ECOD showed an even more sensitive response, ranging from about 2 nmol product formed/g liver/min in Georges Bay to approximately 90 nmol/g liver/min off the tar ponds. CN-ECOD, therefore, appears to be a significantly more sensitive indicator of mono-oxygenase induction than EROD.

In March 1990, a similar suite of measurements was taken along a transect following (roughly) the plume of the River Elbe in the North Sea. Samples of dab (*Limnada limnada*) caught inshore (highly contaminated environments) had EROD activities of around 300 pmol/mg protein/min; those from offshore (less contaminated environments) had activities of 40-100 pmol/mg protein/min. CN-ECOD again showed a more sensitive response, ranging from 2460 and 857 pmole/mg protein/min at two inshore sites to 60-300 pmol/mg protein/min at three offshore sites. Data from the Sydney Harbour area and the North Sea clearly show that indices of mono-oxygenase induction are reliable indicators of the presence of various groups of organic contaminants.

A study of seasonal variation (14-month period) in Cyt. P-450 and mono-oxygenase activity in an (apparently) uncontaminated population of mussels (*Mytilus edulis*) has been completed. EROD activity and benzo (a) pyrene hydroxylase activity were virtually undetectable during the study and showed no consistent seasonal variation. Similarly, no consistent variation in Cyt. P-450 levels could be detected using silver staining of electrophoretograms.

Studies conducted elsewhere during the last 2-3 years have contributed to knowledge of the basic biochemistry of the P-450 system, and have shed some light on the potential for environmental monitoring using invertebrate mono-oxygenase systems. In vertebrates, a component of the mono-oxygenase system (Cyt. P4501A1) is induced by B-naphthoflavone, coplanar PCBs and PAHs. This P450 isozyme catalyses the EROD and (probably) the CN-ECOD reactions. It now appears that P4501A1 evolved at about the same time as the onset of vertebrate evolution. Although P450s occur in invertebrates, they do not belong to the P4501A family and are, therefore, probably not inducible to any appreciable extent by PAH and related compounds. Now that the basic biochemistry of invertebrate P450s is understood, we can now predict with some confidence that invertebrate mono-oxygenases are probably not inducible by PAH etc., and, therefore, are not likely to be useful as indicators of the presence of these chemicals.

Studies of the long-term exposure of fish to hydrocarbon-contaminated sediments has continued. Arctic (Minuk well) cuttings (from a moderate aromatic content OBM) and cuttings from the use of Conoco (low aromatic) OBM were mixed 1:1. Flounder were then exposed to sediments containing about 0.1% oil. Muscle tissues were tested with control fish (triangle test) for off-odour after storage for several months. Results indicated that off-odours developed more in control than in hydrocarbon-exposed fish. It is hypothesised that hydrocarbons accumulated in the tissues may act as an antioxidant and slow down the rate of development of rancidity. Tissue analysis for specific hydrocarbons is being conducted.

As noted above, the main problem encountered has been the mortality of transplanted fish. In view of failure to solve this problem, the approach has been modified by analyzing mono-oxygenase activity in indigenous fish sampled from suspect environments, with a comparable sample from a reference site.

Experimental and field studies supported by PERD and others on various fish species have shown that several indices of mono-oxygenase activity (including kinetic measurements of enzyme activity (EROD and CN-ECOD) and immunochemical measurements of P450 isozymes) are reliable indicators of contamination by low levels of various organic compounds. Provided a monitoring species is carefully selected, spatial variation in the effects of environmental contamination on indigenous populations can be detected with a resolution of a few km. Fish hepatic mono-oxygenase activity (EROD) has already been selected as one of the indices of sub-lethal effects of environmental contamination, which will be measured by the Joint Monitoring Group (JMG) to assess the impact of ocean dumping. It is recommended that such techniques should be applied in Canada on a pilot scale to assess the potential impact of organic chemical contamination from various sources.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study is of direct relevance to BEMP Hypotheses Nos. 13 and 20, and MEMP Hypothesis 15B, in which reductions in harvest and palatability of fish are linked to accumulation of hydrocarbons in fish tissue. Reduction in harvest results from decreased desirability of fish flesh due to taint as a result of hydrocarbon accumulation (BEMP 13 and MEMP 15B) or as a result of reductions in population size as a result of toxic effects of hydrocarbon accumulation through the food chain (BEMP 20).

The development of reliable techniques to monitor the exposure of fish to hydrocarbons is important to understanding the effects (at the individual and population level) of chronic exposures of fish to low level concentrations of hydrocarbons.

REFERENCES

Addison, R. F. and K. R. Clarke. In Press. The IOC/GEEP Bermuda Workshop. J. Exp. Mar. Biol. Ecol. (Partial PERD support.)

Stegeman J. J., K. W. Renton, B.R. Woodin, Y. S. Zhang and R.F. Addison. In Press. Experimental and environmental induction of cytochrome P. 450E in fish from Bermuda waters. J. Exp. Mar. Bio. Ecol. In press. (Partial PERD support)

Payne, J. F., J. Kiceniuk, L. L. Fancey, U. Williams, G.L. Fletcher, A. Rahimtula and B. Fowler. 1989. What is a safe level of polycyclic aromatic hydrocarbons for fish: Subchronic toxicity study on winter flounder (*Pseudopleuronectes americanus*). Can. J. Fish. Aquat. Sol. 45: 1983-1993.

Payne J.F. and L.L. Fancey. 1989. Effect of polycyclic aromatic hydrocarbons on immune responses in fish: change in melano-macrophage centers in flounder (*Pseudopleuronectes americanus*) exposed to hydrocarbon-contaminated sediments. Presented at Fifty International Symposium on Responses of Marine Organisms to Pollutants, Plymouth, April 1989.

Porter E., J.F. Payne, J. Kiceniuk, L. Fancey and W. Melvin. 1989. Assessment of the potential for mixed-function oxygenase induction in the extrahepatic tissues of cunners during reproduction. Presented at Fifth International Symposium on Responses of Marine Organisms to Pollutants, Plymouth, April 1989.

Condensate Effects on Commercial Species (PERD No. 67238)

BREAM PROJECT OVERVIEW NO. B13-14

PRINCIPAL INVESTIGATOR:	R.J. Percy
AFFILIATION:	Environment Canada
FUNDING SOURCE:	PERD
COMPLETION DATE:	1994
RELEVANT HYPOTHESIS NO:	BEMP 13 and 20 Future impact hypotheses dealing with oil spills

BRIEF PROJECT DESCRIPTION

The objectives of this multi-year study are to:

(1) examine tainting in a lipid-rich fish exposed to water-soluble fraction of oil (1990-91) in order to examine lipid level as a factor in tainting and to compare the results to previous tainting studies involving low lipid-level animals;

(2) examine the tainting potential of oil-based/low-toxicity muds (1991/1992);

(3) ascertain which components of condensate are responsible for the tainting observed during completion of the original study using the sea scallop (1992/93); and

(4) complete tainting studies identified as a priority by PERD Workshop (1993/94).

Recent studies (including PERD No. 67238) have clearly shown that the water-soluble fraction (WSF) of various crude oils and natural gas condensate can induce tainting in fish and scallops. Several studies in the North Sea have also indicated a marginal degree of tainting in flatfish exposed to various hydrocarbon contaminants around oil platforms. None of these studies have clearly identified the individual tainting components in the myriad of hydrocarbon compounds that the animals have been exposed to. Various studies have suggested that the lower boiling components may be responsible for tainting. An exposure experiment is required to help pinpoint those common components of WSFs that are responsible for tainting. Unlike several Japanese studies in which tissues were spiked with hydrocarbons prior to taste panel assessment, an exposure setup is required to simulate natural uptake and taste alteration in exposed animals. It is recommended that sea scallops (*Placopecten magellanicus*) be used because of their acceptability to lab conditions and the fairly extensive data base now available on tainting in scallops.

Tainting has been examined in some low-lipid fish and invertebrates (cod and scallops). However, the lipid content of the exposed animal has also been suggested as a variable in the tainting threshold of animals exposed to WSF of oil. Fish with higher lipid levels have not been properly examined in the exposure system, which is currently used for tainting work. An extreme example would be herring or mackerel with very high lipid content. However, these fish are difficult to work with and keep in a laboratory environment. An intermediate-lipid level fish is salmon, which is relatively easy to keep and work with in the lab. The purpose of this study would be to look at lipid level as a factor in tainting and to compare the results to previous tainting studies involving low-lipid animals.

Oil-based drilling muds are currently being used in frontier exploration in Canada and are likely to be used in any future development drilling. The tainting potential of low-toxicity oils released from discharged drilling muds requires examination. It is proposed that such a study be conducted after the results of tainting work described above are available since the oil/mud situation represents a much more complicated challenge.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study will provide information on various oil fractions and the influence of lipid content on fish tainting. This will enhance the level of understanding of tainting dynamics so that the on-going issue of fish tainting in oil exploration/production areas can be managed effectively.

The Evaluation and Selection of an Analytical Method to Detect a Hydrocarbon Taint in Fish

BREAM PROJECT OVERVIEW NO. B13-15

PRINCIPAL INVESTIGATOR:	M.C. Hamilton
AFFILIATION:	Seakem Oceanography Ltd.
FUNDING SOURCE:	PERD
COMPLETION DATE:	1991
RELEVANT HYPOTHESIS NO.:	BEMP 13 and 20 Future impact hypotheses dealing with oil spills

BRIEF PROJECT DESCRIPTION

As taint is a subjective sensory perception, studies of the development of a taint in fish have been hampered in the past by difficulties in identifying the causative tainting agents.

In order to establish objective chemical criteria for taint in fish, a standard chemical protocol is necessary. This study is directed at filling this need in two phases:

(1) to select a target list of compounds potentially responsible for taint (based on a literature survey), and

(2) to evaluate, select and validate a method for testing that would be used to develop a screening test for tainted fish.

RELATIONSHIP AND RELEVANCE TO BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

The possibility of taint in fish or other animals is always an important issue in discussions of possible impacts of offshore oil and gas activities in the Arctic. Having a validated method for screening for a taint will be valuable in assessing potential tainting issues quickly and objectively (in conjunction with taste tests).

Tainting/contamination Potential of Weathered Oil Particulates for Commercially-important Fish Species

BREAM PROJECT OVERVIEW NO. B13-16

PRINCIPAL INVESTIGATORS:	J.F. Payne
AFFILIATION:	Department of Fisheries and Oceans
FUNDING SOURCE:	PERD
EXPECTED COMPLETION DATE:	1993
RELEVANT HYPOTHESIS NO.:	BEMP 13 and 20 Future impact hypotheses dealing with oil spills

BRIEF PROJECT DESCRIPTION

This study is directed at the possibility of fish acquiring a taint by ingesting weathered tar balls resulting from major or minor oil spills. It will investigate this possibility both for pelagic fish and benthic fish that may come into contact with sunken oil particulates. Outputs of the study will include a quantification of the weathered oil required to effect tainting and contamination in two fish species – codfish (pelagic) and American plaice (benthic). Tar balls will be prepared from weathered Hibernia and Terra Nova crude oils, and fish will be fed varying amounts by intubation to establish threshold dose responses. The benthic fish will be fed various amounts of weathered oil-contaminated sediment.

RELATIONSHIP AND RELEVANCE TO BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

The results of this study will provide the first direct information as to the potential for fish to become tainted following exposure to weathered oils in tar balls or sediment particulates. This is important to evaluate long-term taint potential, which is particularly relevant to the benthic environment.

Coastal Zone Geotechnics (Beaufort Sea)

BREAM PROJECT OVERVIEW NO. B13-17

PRINCIPAL INVESTIGATORS:	Steve Solomon[1], Don Forbes[1] and Phil Hill[2]
AFFILIATIONS:	[1]Atlantic Geoscience Centre and [2]Hill Geoscience Ltd.
FUNDING SOURCE:	NOGAP and EMR/GSC
EXPECTED COMPLETION DATE:	Ongoing
RELEVANT HYPOTHESIS NO.:	BEMP 13 and 19

BRIEF PROJECT DESCRIPTION

This project has a number of components related to coastal stability, nearshore sediment transport and nearshore sedimentation. Field programs conducted during 1989 and 1990 focussed on surficial sediment properties and stratigraphy and coastal erosion measurements. Field studies planned for 1991 will include current meter studies of nearshore currents, directional wave spectra and shallow-water high resolution geophysics.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study is of indirect relevance to BEMP Hypothesis No. 13 (fish harvest reductions due to shorebase discharges of hydrocarbons or heavy metals), and Hypothesis No. 19 (dredging and deposition of spoils will reduce benthic invertebrate, fish and bearded seal populations). In the case of the Hypothesis No. 13, data collected as part of this study can be used in modelling of contaminant dispersion. Similarly for Hypothesis No. 19, results from the study may be used to calibrate sediment transport models that are used to predict zones of influence of dredge spoil.

Current studies conducted during 1991 may have direct relevance to Hypotheses 14 and 15, disruption of nearshore currents or hydrography could reduce broad whitefish or arctic cisco populations, respectively. The background data being collected during this study will help in determining pre-construction impact.

REFERENCES

Davidson, S., S. de Margerie and K. Lank. 1988. Sediment transport in the Mackenzie plume. Contractor report by ASA Consulting, Dartmouth, NS for the Atlantic Geoscience Centre.

Hill, P.J. and O. Nadeau. 1989. Mackenzie River plume characteristics in the nearshore of the Canadian Beaufort Sea. Journal of Petroleum and Sedimentary Petrology 59:455-468.

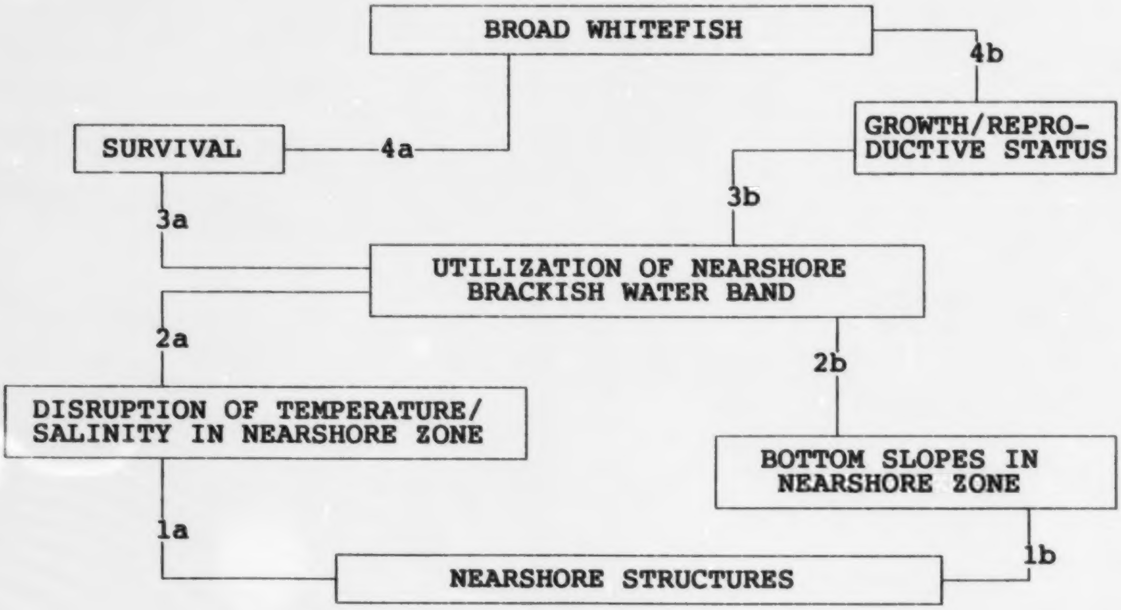
Hill, P.R., S.M. Blasco, J.R. Harper and D.B. Fissel. In Press. Sedimentation on the Canadian Beaufort Shelf. Journal of Continental Shelf Research.

OTHER RELEVANT PROJECTS

PROJECT	TITLE	PAGE
BEMP 1-1	Beaufort Sea oceanography	85
BEMP 2-3	A draft community-based Regional Land Use Plan for the Mackenzie Delta-Beaufort Sea region	139
BEMP 2-4	Inuvialuit harvest study	140
BEMP 2-5	Environmental atlas for Beaufort Sea oil spill response	141
BEMP 10-1	Nearshore sediment transport and dynamics	176

BEMP HYPOTHESIS NO. 14

NEARSHORE STRUCTURES WILL DISRUPT THE NEARSHORE BAND OF WARM BRACKISH WATER AND REDUCE THE BROAD WHITEFISH POPULATION


BROAD WHITEFISH
4b
GROWTH/REPRODUCTIVE STATUS
SURVIVAL
4a
3b
3a
UTILIZATION OF NEARSHORE BRACKISH WATER BAND
2a
2b
DISRUPTION OF TEMPERATURE/SALINITY IN NEARSHORE ZONE
BOTTOM SLOPES IN NEARSHORE ZONE
1a
1b
NEARSHORE STRUCTURES

LINKAGES

1a. Shoreline modifications will change temperature and salinity characteristics of the brackish water band along the Tuktoyaktuk Peninsula.

1b. Nearshore structures will change the slope of the sea bottom within the brackish water band along the Tuktoyaktuk Peninsula.

2a. Disruption of the brackish water band will result in decreased utilization of the nearshore zone by broad whitefish.

2b. Changes in nearshore sea bottom slope will alter utilization of nearshore waters by broad whitefish.

3a. The reduced time spent in the nearshore brackish zone will cause an increase in mortality of broad whitefish.

3b. Disruption of nearshore habitat will cause a decrease in feeding time and consequently a reduction in growth and fecundity.

4a. Increase in mortality of broad whitefish would lead to decrease in the number of spawners, and subsequent reduction in the number of harvestable fish.

4b. Reduction in fecundity and reduced viability of eggs and young would result in fewer available fish for the harvest.

Broad Whitefish Stock Differentiation

BREAM PROJECT OVERVIEW NO. B14-1

PRINCIPAL INVESTIGATOR:	J.D. Reist
AFFILIATION:	Department of Fisheries and Oceans, Freshwater Institute
FUNDING SOURCE:	DFO and NOGAP
EXPECTED COMPLETION DATE:	Unknown
RELEVANT HYPOTHESIS NO.:	BEMP 14, 16 and 17 MEMP 14

BRIEF PROJECT DESCRIPTION

The objective of this study is to determine the discreteness and number of broad whitefish (*Coregonus nasus*) stocks in the Mackenzie River drainage using morphometric, meristic, and electrophoretic techniques. Samples of whitefish have been collected from the Mackenzie Delta and at several locations upstream. These specimens are being examined to determine the usefulness of specific characteristics as stock identifiers.

To date, approximately 2500 fish have been collected from the study area and from Alaska (for comparative purposes). Processing included taking 20 measurements, 9 meristic counts, 4 measurements of biological parameters, examining fish for scarring and external parasites, and extracting muscle, heart, and liver tissue for biochemical analyses. Data analysis and report preparation is currently underway. Beginning in 1990, a supplementary project was initiated to investigate whitefish population dynamics on a stock-by-stock basis using data accrued from previously collected samples.

To date, results indicate that broad whitefish in the lower Mackenzie River are structured into distinct genetic stocks on the basis of one or more of the following:

(1) within-year spawning aggregations associated with major features of the lower Mackenzie Basin (e.g., tributaries such as Peel and Arctic Red rivers);

(2) possibly between successive years within spawning areas;

(3) likely as migratory groups moving to and, perhaps, from spawning areas;

(4) as juveniles in rearing areas such as the lakes of the Tuktoyaktuk Peninsula; and

(5) as life history types (e.g., an anadromous form exhibiting typical migratory behaviour to and from spawning sites; a lacustrine form spending most of its life history within larger lake systems; and a non-anadromous riverine form).

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This project is of relevance to all hypotheses concerning broad whitefish because it will provide data that will aid in assessing possible effects of hydrocarbon development on this species. If separate populations of broad whitefish exist in the region, they may be more susceptible to some development activities, particularly if such populations remain as discrete units while in the Beaufort coastal area. Genetic structuring of broad whitefish populations within the region also has profound implications for fisheries management and planning for mitigation of environmental impacts.

REFERENCES

Reist, J.D. and W.A. Bond. 1988. Life history characteristics of migratory coregonids of the lower Mackenzie River, Northwest Territories, Canada. Finnish Fisheries Research 9: 133-144.

Bodaly, R.A., J.D. Reist, D.M. Rosenberg, P.J. McCart and R.E. Hecky. 1989. Fish and fisheries of the Mackenzie and Churchill river basins, northern Canada. Pages 128-144. *In:* D.P. Dodge [ed.]. Proceedings of the International Large River Symposium. Can. Spec.: Publ. Fish. Aquat. Sci. 10.

Identification of Coregonids

BREAM PROJECT OVERVIEW NO. B14-2

PRINCIPAL INVESTIGATOR:	J.D. Reist
AFFILIATION:	Department of Fisheries and Oceans, Freshwater Institute
FUNDING SOURCE:	DFO and NOGAP
EXPECTED COMPLETION DATE:	Unknown
RELEVANT HYPOTHESIS NO.:	BEMP 14, 15, 16 and 17 MEMP 14 and 16

BRIEF PROJECT DESCRIPTION

As a background activity to other initiatives, data on key diagnostic characters that define and identify coregonids of different sizes and ages to species have been collected. Proper identification criteria for young coregonids have not been previously developed.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

Species level identification at all stages of fish species development is essential to obtaining knowledge of the size of regional populations of coregonids and to assessment of risk to populations from exploitation and development activities. This project addresses fundamental knowledge gaps.

Hybridization of Coregonids

BREAM PROJECT OVERVIEW NO. B14-3

PRINCIPAL INVESTIGATOR:	J.D. Reist
AFFILIATION:	Department of Fisheries and Oceans, Freshwater Institute
FUNDING SOURCE:	DFO and NOGAP
EXPECTED COMPLETION DATE:	Unknown
RELEVANT HYPOTHESIS NO.:	BEMP 14, 15, 16 and 17 MEMP 14 and 16

BRIEF PROJECT DESCRIPTION

Field collections in the Wood Bay area of likely hybrid specimens of arctic coastal coregonids have indicated that most coregonids in the western Arctic hybridize freely and the rates of such hybridization are very high.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This work provides information of general importance to all hypotheses that have coregonid protection and management implications. The extent to which hybridization is leading to reproductively viable fish stocks and the potential for increase in hybridization as a result of environmental disturbance is presently unknown. Increases could lead to species breakdown with consequential severe management implications.

External Scarring of Whitefish, *Coregonus nasus* and *C. clupeaformis* complex, from the Western Northwest Territories, Canada

BREAM PROJECT OVERVIEW NO. B14-4

PRINCIPAL INVESTIGATOR:	J.D. Reist
AFFILIATION:	Department of Fisheries and Oceans, Freshwater Institute
FUNDING SOURCE:	DFO and NOGAP
EXPECTED COMPLETION DATE:	Unknown
RELEVANT HYPOTHESIS NO.:	BEMP 14, 15, 16 and 17 MEMP 14 and 16

BRIEF PROJECT DESCRIPTION

Up to 40 percent of whitefish sampled during spawning migrations in the Mackenzie Delta area had external scars. Percent frequency of scarred individuals varied geographically among the Mackenzie mainstem and tributaries, the Anderson River, Cox Lake, and Alaska. Small round scars were restricted to fish that were in locations with connections to the Arctic Ocean and were probably caused by the marine parasite *Coregonicola* or by Arctic lampreys (*Lampetra japonica*). Larger round scars were either the result of attacks by lampreys or previous gillnet capture. Unequal distribution and orientation on the body of slash scars indicated previous capture in gill nets or predation attempts by bears, birds or piscivorous fishes. Accrual of data on this phenomenon is ongoing for a variety of fish taxa.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

The results of this study will be relevant to BEMP Hypotheses 14 to 17 and MEMP Hypotheses 14 and 16. This study illustrates the possible need to revise MEMP Hypothesis 14, since results indicate that increased fishing pressure could decrease the quality of fish. This could come about because scarring (caused by previous gillnet capture) could reduce the attractiveness and saleability of whitefish. A surprisingly large number of fish examined from the Mackenzie River were scarred.

REFERENCE

Reist, J.D., R.A. Bodaly, R.J.P. Fudge, K.J. Cash and T.V. Stevens. 1987. External scarring of whitefish, *Coregonus nasus* and *C. clupeaformis* complex, from the western Northwest Territories, Canada. Can. J. Zool. 65: 1230-1239.

Broad Whitefish Population Dynamics

BREAM PROJECT OVERVIEW NO. B14-5

PRINCIPAL INVESTIGATOR:	J.D. Reist
AFFILIATION:	Department of Fisheries and Oceans, Freshwater Institute
FUNDING SOURCE:	DFO and NOGAP
EXPECTED COMPLETION DATE:	Unknown
RELEVANT HYPOTHESIS NO.:	BEMP 14, 15, 16 and 17 MEMP 14 and 16

BRIEF PROJECT DESCRIPTION

Basic stock-by-stock parameters relevant to broad whitefish population dynamics will be ascertained using previously collected data and results from ongoing exploratory fisheries. These data will be used to establish stock structure and assess the effects of impacts on the stocks.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This project provides fundamental knowledge of relevance to all hypotheses that deal with the effects of development on the protection and management of broad whitefish.

The Investigation of Food Chains and Fish Migration Using the Stable Isotopes of Sulfur, Carbon, and Nitrogen

BREAM PROJECT OVERVIEW NO. B14-6

PRINCIPAL INVESTIGATOR:	R.H. Hesslein
AFFILIATION:	Department of Fisheries and Oceans, Freshwater Institute
FUNDING SOURCE:	DFO and NOGAP
EXPECTED COMPLETION DATE:	Unknown
RELEVANT HYPOTHESIS NO.:	BEMP 14, 15, 16 and 17

BRIEF PROJECT DESCRIPTION

The objectives of the project are to determine the importance of various feeding habitats of fish (especially broad whitefish) and their movements between these locations. The study was initiated in 1986 and continues at a slow rate because of reduced resources. Samples of fish have been supplied primarily from the collections of J. Reist, as well as collections of R. Heckey's NOGAP group.

The investigation is based on the ability to distinguish different food chains on the basis of the sulfur isotope signal, and to delineate the structure of food chains using stable isotopes of carbon and nitrogen. To date, the structure of three representative food chains has been detailed: the Kukjuktuk Creek system on the Tuktoyaktuk Peninsula; Mackenzie Delta lakes studied by R. Hecky's NOGAP group; and Travaillant Lake, a tributary system to the Mackenzie River.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

Results of this research will provide information for assessing the importance of access to fresh water vs. coastal feeding habitats to the survival of coregonid populations of the region.

REFERENCES

Hesslein, R.H., M.J. Capel, D.E. Fox and K.Hallard. Under Review. Stable isotopes of sulfur, carbon, and nitrogen as indicators of aquatic food web relationships and fish migration in two lakes of the Mackenzie River. Can. J. Fish. Aquat. Sci.

Hesslein, R.H., D.E. Fox and M.J. Capel. 1989. Sulfur, carbon, and nitrogen isotopic composition of fish from the Mackenzie River delta region and other Arctic drainages. Can. Data Rep. Fish. Aquat. Sci. 728: iv + 11 p.

Hesslein, R.H., M.J. Capel, D.E. Fox and K. Hallard. In Press. Stable isotopes of sulfur and carbon as tracers of feeding locations among broad whitefish populations in the lower Mackenzie River basin: preliminary results. Proceedings of the Mackenzie Delta Workshop, Saskatoon, Sept. 1989.

Overwintering Fish Habitat in the Nearshore Beaufort and Mackenzie Delta

BREAM PROJECT OVERVIEW NO. B14-7

PRINCIPAL INVESTIGATORS:	A. Sekerak and W. Griffiths
AFFILIATION:	LGL Limited
FUNDING SOURCE:	Unknown
EXPECTED COMPLETION DATE:	Unknown
RELEVANT HYPOTHESIS NO:	BEMP 14, 15 and 16 MEMP 16

BRIEF PROJECT DESCRIPTION

The objectives of this study are to obtain and synthesize available published and unpublished information on fish overwintering habitat, to document and map areas of known importance, and to identify data gaps. Mapping should include a habitat classification system and priorities.

Many fish populations are concentrated in small areas during winter, which may make them more susceptible to disturbance by oil and gas exploration, development and production activities. At present, published information on the location and importance of overwintering fisheries habitat in the nearshore Beaufort Sea and Mackenzie Delta is not sufficient to adequately assess potential development-related impacts and mitigative measures.

Information on overwintering habitat would be used by both industry and government to: (1) minimize impacts during seismic and other exploration activities; (2) assess alternative production facility sites; (3) select pipeline routes; (4) assess potential development impacts; and (5) develop environmental protection plans for construction and operations. The regional assessment of overwintering habitat proposed here will form the basis for future site-specific studies by industry and government. It will also contribute to development of a broader fish habitat information system for this area.

Species to be examined include broad whitefish, lake whitefish, Arctic cisco, least cisco, inconnu, Pacific herring, Arctic charr, burbot, lake trout, northern pike, Arctic grayling, rainbow smelt and saffron cod. The area to be investigated includes the nearshore Beaufort Sea (shoreline to 10 metre isobath) from the United States border east to the Anderson River, including the Tuktoyaktuk Peninsula, Eskimo Lakes and Liverpool Bay. It also includes the Mackenzie River and tributaries downstream of Arctic Red River, as well as freshwater overwintering areas along the Yukon North Slope.

This study is intended to integrate local, traditional and scientific knowledge of overwintering fish habitat in this region. Known sources of such data include both published and unpublished literature.

This study is currently being conducted, and final results are not yet available. However, it appears that the major objectives of the program will be met and the study will be of use in planning any exploration or development activity in the region.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study will provide information relevant to assessing linkages 3a and b of BEMP Hypothesis No. 14, and linkages 7 and 8 of MEMP Hypothesis No. 16 insofar as it will provide information on the availability and importance of overwintering habitat in the nearshore brackish waters to broad whitefish.

Fisheries Research in the Mackenzie valley

BREAM PROJECT OVERVIEW NO. B14-8

PRINCIPAL INVESTIGATOR:	N. Robinson
AFFILIATION:	Department of Fisheries and Oceans, Western Arctic area
FUNDING SOURCE:	DFO
EXPECTED COMPLETION DATE:	Unknown
RELEVANT HYPOTHESIS NO.:	BEMP 14 MEMP 13, 14 and of general interest

BRIEF PROJECT DESCRIPTION

The Department of Fisheries and Oceans, Western Arctic Region will be undertaking several projects in 1991-92.

(1) A whitefish exploratory fishery will be conducted in the Mackenzie River Delta. This is an ongoing project to determine the feasibility of a commercial fishery in the area.

(2) A deflection board weir will be set up on the Babbage River. This is part of a 3-year program to establish an ecological model for management of North Slope Arctic charr.

(3) A deflection board weir will be set on the Big Fish River to establish a total allowable catch. This year is the end of a five-year fishing closure on the river.

(4) A monitoring program will be implemented to monitor the Rat, Hornaday, Peel and Arctic Red river fisheries.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROGRAM

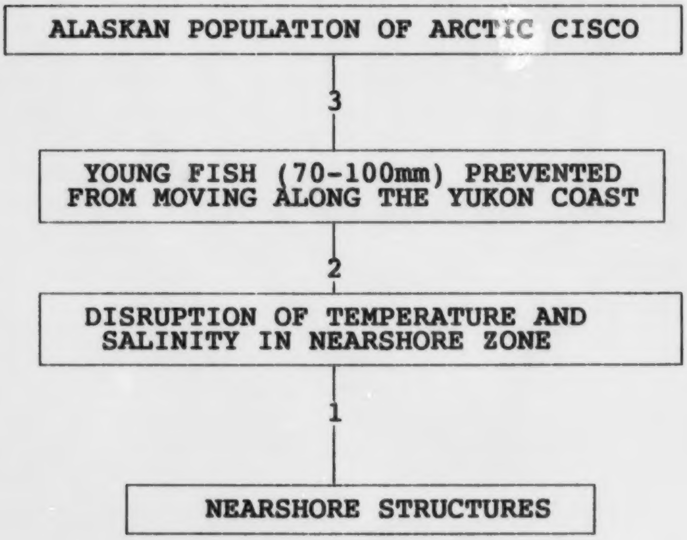
These four studies focus on providing information to improve or develop new harvest management strategies. Fisheries protection priorities will benefit from information derived from these studies.

OTHER RELEVANT PROJECTS

PROJECT	TITLE	PAGE
—	No other Project Overviews are directly relevant to BEMP Hypothesis No. 14	—

BEMP HYPOTHESIS NO. 15

NEARSHORE STRUCTURES WILL DISRUPT THE NEARSHORE BAND OF WARMER BRACKISH WATER AND WILL REDUCE THE ALASKAN POPULATION OF ARCTIC CISCO


ALASKAN POPULATION OF ARCTIC CISCO
3
YOUNG FISH (70-100mm) PREVENTED FROM MOVING ALONG THE YUKON COAST
2
DISRUPTION OF TEMPERATURE AND SALINITY IN NEARSHORE ZONE
1
NEARSHORE STRUCTURES

LINKAGES

1. Shoreline modification will change temperature and salinity patterns of the brackish water band along the Yukon Coast during summer.

2. Disruption of the brackish water band will result in decreased movement of young arctic cisco from the Mackenzie Delta to the Alaskan Beaufort Sea coast.

3. Decreased movement of arctic cisco will cause directly proportional decreases in the Alaskan population of arctic cisco.

Arctic Cisco Migrations and Life History

BREAM PROJECT OVERVIEW NO. B15-1

PRINCIPAL INVESTIGATOR:	W.A. Bond
AFFILIATION:	Department of Fisheries and Oceans, Freshwater Institute
FUNDING SOURCE:	DFO and NOGAP
EXPECTED COMPLETION DATE:	Unknown
RELEVANT HYPOTHESIS NO.:	BEMP 15 MEMP 14

BRIEF PROJECT DESCRIPTION

Large numbers of Arctic cisco are thought to migrate annually from the Mackenzie River westward to the Colville Delta, travelling within a narrow, nearshore band of relatively brackish water. Having reached the Colville River, these fish remain associated with the river for several years. Upon reaching sexual maturity at age 6-8, they return to the Mackenzie to join the spawning population. Such a pattern is highly susceptible to disruption by events that destroy or degrade critical areas such as spawning or rearing sites, or that result in the inability of fish to migrate from one area to another.

The degree to which Mackenzie River spawning stocks are dependent on Colville-reared fish is uncertain. Is the Colville the only such area on the Beaufort coast, or are there other areas that serve an important role? Surveys have shown that Arctic cisco also disperse eastward in early summer along the coast of the Tuktoyaktuk Peninsula and return to the Mackenzie Delta in autumn. The lack of information on the distribution of Arctic cisco to the east of the Mackenzie represents a major gap in our understanding.

The purpose of this study is to monitor and describe the coastal migrations of Arctic cisco in Wood Bay near the mouth of the Anderson River. Long-term objectives are: (1) to determine whether major rearing/overwintering of juvenile Arctic cisco from the Mackenzie River occurs east of the Mackenzie Delta; (2) to identify specific areas to the east of the Mackenzie Delta that may be critical to the maintenance of Mackenzie River Arctic cisco stocks; and (3) to quantify the significance of eastern locations to Mackenzie River populations.

In 1990, fish populations were monitored in the inner estuary of the Anderson River using gillnets until the end of June, by which time the ice had receded far enough to permit the installation of traps in the outer estuary. Floy tags have been applied to 3200 Arctic cisco. No recoveries have been reported to date outside the Wood Bay area. In 1991, focus will be placed on monitoring movement patterns within Liverpool Bay. Nearshore movements are to be described using trap nets, while gillnets will be employed to monitor movements in deeper offshore waters.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

The degree to which areas east of the Mackenzie River provide rearing habitat and overwintering habitat for Mackenzie River populations is important to understanding the significance of the Colville R. (Alaska) to this population. The severity of effects resulting from blockage of access to the Colville may be, to some extent, offset by the presence of alternative rearing areas in Wood Bay/Anderson River.

REFERENCES

Bond, W.A. and R.N. Erickson. 1987. Fishery data from Phillips Bay, Yukon, 1985. Can. Data Rep. Fish. Aquat. Sci. 635.

Bond, W.A. and R.N. Erickson. 1989. Summer studies of nearshore fish communities at Phillips Bay, Beaufort Sea coast, Yukon. Can. Tech. Rep. Fish. Aquat. Sci. 1676.

Coastal Migrations of Arctic Cisco

BREAM PROJECT OVERVIEW NO. B15-2

PRINCIPAL INVESTIGATOR:	K.T.J. Chang-Kue
AFFILIATION:	Department of Fisheries and Oceans, Freshwater Institute
FUNDING SOURCE:	DFO and NOGAP
EXPECTED COMPLETION DATE:	Unknown
RELEVANT HYPOTHESIS NO.:	BEMP 15 MEMP 14

BRIEF PROJECT DESCRIPTION

The objectives of this research were: (1) to test the applicability of using radio tags on arctic ciscos; and (2) to determine the range of movements, timing, and migration rates of adult and juvenile Arctic cisco from selected areas east of the Mackenzie Delta (particularly the Liverpool Bay/Anderson River area). Specific hypotheses to be tested were:

(1) immature Arctic cisco in the Anderson River area have limited movement around the Anderson River delta;

(2) the Anderson Delta is the sole overwintering site for these immature Arctic ciscos; and

(3) mature fish from Tuktoyaktuk Harbour and Anderson River migrate to the Mackenzie River for spawning.

Arctic cisco will be tagged with radio transmitters soon after ice-out, and subsequent movements will be tracked using fixed-wing aircraft. On 1-2 July 1990, 12 Arctic cisco (age 6-10 years) were tagged with radio tags at Tuktoyaktuk Harbour. Tracking indicated that both eastward and westward movements occurred along the coast. Migration rates of 7-17 km/day were demonstrated by a few fish moving towards the Mackenzie Delta. By 31 July, four fish had moved to the delta; their placement was consistent with known spawning behaviour. Of 19 Arctic cisco dissected, 42% were mature fish and judged as likely to spawn in the fall. Tagging and radio tracking will continue until at least 1993.

To test the applicability of using radio tags on Arctic cisco, ten fish were tagged with external mount tags and kept in a holding pen. Although all fish survived the tagging procedure, survival was poor after one week, with only 4 fish considered to be in good condition. Unnatural confinement of this active species may have contributed to poor survival.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

The degree to which areas east of the Mackenzie River provide rearing habitat and overwintering habitat for Mackenzie River populations is important to understanding the significance of the Colville R. (Alaska) to this population. The severity of effects resulting from blockage of access to the Colville may be, to some extent, offset by the presence of alternative rearing areas in Wood Bay/Anderson River.

Arctic Cisco Stock Differentiation

BREAM PROJECT OVERVIEW NO. B15-3

PRINCIPAL INVESTIGATOR:	J.D. Reist
AFFILIATION:	Department of Fisheries and Oceans, Freshwater Institute
FUNDING SOURCE:	DFO and NOGAP
EXPECTED COMPLETION DATE:	Unknown
RELEVANT HYPOTHESIS NO.:	BEMP 15, 16 and 17 MEMP 14 and 16

BRIEF PROJECT DESCRIPTION

The purpose of this study is to determine the discreteness and number of arctic cisco stocks in the lower Mackenzie River, and to determine their distribution east and west of the Mackenzie River. Samples have been collected from mainstem and coastal locations, and preliminary analyses are underway.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

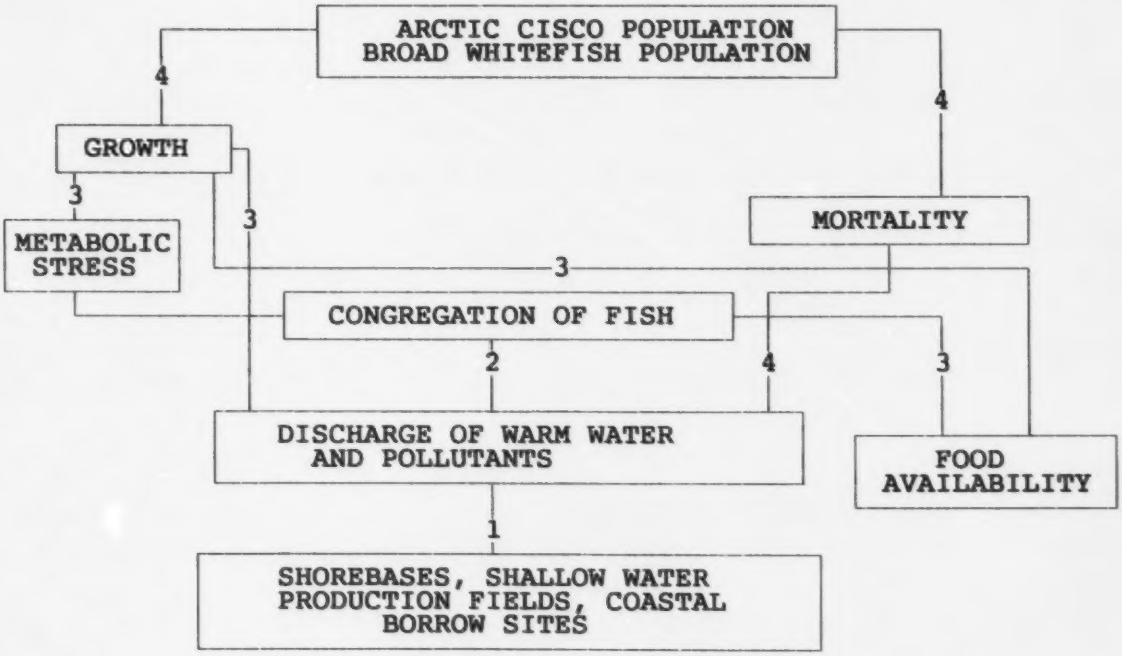
This project is of relevance to all hypotheses concerning Arctic cisco because it will provide data that will aid in assessment of possible effects of hydrocarbon development on this species. If separate populations of Arctic cisco exist in the region, they may be more susceptible to some development activities, particularly if such populations remain as discrete units while in the Beaufort coastal area. Genetic structuring of Arctic cisco populations within the region also has profound implications for fisheries management and planning for mitigation of environmental impacts.

OTHER RELEVANT PROJECTS

PROJECT	TITLE	PAGE
BEMP 14-2	Identification of coregonids	234
BEMP 14-3	Hybridization of coregonids	235
BEMP 14-4	External scarring of whitefish, *Coregonus nasus* and *C. clupeaformis* complex, from the western Northwest Territories, Canada	236
BEMP 14-5	Broad whitefish population dynamics	237
BEMP 14-6	The investigation of food chains and fish migration using the stable isotopes of sulphur, carbon and nitrogen	237
BEMP 14-7	Overwintering fish habitat in the nearshore Beaufort and Mackenzie Delta	239

BEMP HYPOTHESIS NO. 16

THE CONSTRUCTION OF SHOREBASES AND DEVELOPMENT OF SHALLOW-WATER PRODUCTION FIELDS WILL RESULT IN A DECREASE IN THE POPULATIONS OF ARCTIC CISCO AND BROAD WHITEFISH


ARCTIC CISCO POPULATION
BROAD WHITEFISH POPULATION
4
4
GROWTH
3
3
METABOLIC STRESS
MORTALITY
3
CONGREGATION OF FISH
2
4
3
DISCHARGE OF WARM WATER AND POLLUTANTS
FOOD AVAILABILITY
1
SHOREBASES, SHALLOW WATER PRODUCTION FIELDS, COASTAL BORROW SITES

LINKAGES

1. Warm water effluents and production water will be discharged into the freshwater area of the outer Mackenzie Delta.
2. Fish will be attracted to thermal plumes.
3. Contaminants in produced water in areas where fish are congregated will result in increased stress, reduced food availability and decreased fish growth.
4. Direct mortality due to effluents and decreased growth will reduce arctic cisco and broad whitefish populations.

RELEVANT PROJECTS

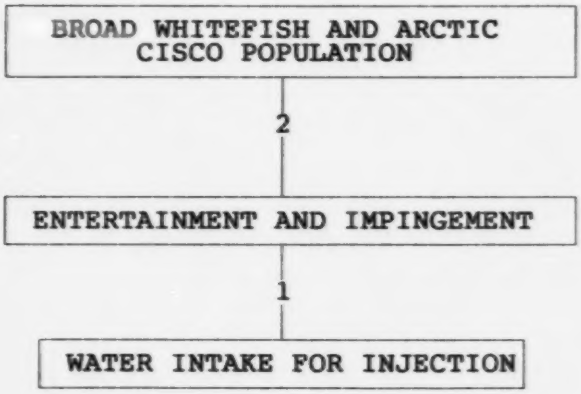
PROJECT	TITLE	PAGE
BEMP 1-3	The distribution of nutrients in the southeastern Beaufort Sea: implications for water circulation and primary production	87
BEMP 1-4	Production studies in the Mackenzie River-Beaufort Sea estuary	88
BEMP 1-5	Ecological factors governing the distribution and abundance of the copepod, *Limnocalanus macrurus*, in the Beaufort Sea	90
BEMP 1-6	Zooplankton and bowhead whale feeding in the Canadian Beaufort Sea, 1986	92
BEMP 1-7	Zooplankton of a bowhead whale feeding area off the Yukon coast in August 1986	94
BEMP 1-10	Zooplankton distributions in the southeastern Beaufort Sea, summer 1987	99
BEMP 1-11	Distribution and life history of *Limnocalanus macrurus*, an estuarine copepod, in the Beaufort Sea	101
BEMP 14-1	Broad whitefish stock differentiation	233

RELEVANT PROJECTS (Continued)

PROJECT	TITLE	PAGE
BEMP 14-2	Identification of coregonids	234
BEMP 14-3	Hybridization of coregonids	235
BEMP 14-4	External scarring of whitefish, *Coregonus nasus* and *C. clupeaformis* complex, from the western Northwest Territories, Canada	236
BEMP 14-5	Broad whitefish population dynamics	237
BEMP 14-6	The investigation of food chains and fish migration using the stable isotopes of sulphur, carbon and nitrogen	237
BEMP 14-7	Overwintering fish habitat in the nearshore Beaufort and Mackenzie Delta	239
BEMP 15-3	Arctic cisco stock differentiation	245

BEMP HYPOTHESIS NO. 17

WATER INTAKES WILL REDUCE POPULATIONS OF BROAD WHITEFISH AND ARCTIC CISCO


BROAD WHITEFISH AND ARCTIC CISCO POPULATION
2
ENTERTAINMENT AND IMPINGEMENT
1
WATER INTAKE FOR INJECTION

LINKAGES

1. The intake of water for reservoir injection will cause entrainment and impingement of juvenile broad whitefish and arctic cisco.

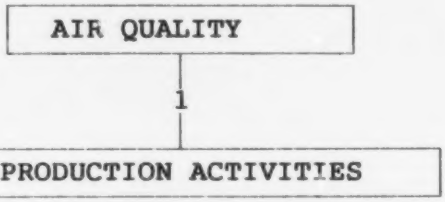
2. The mortality associated with entrainment and impingement will reduce broad whitefish and arctic cisco populations.

RELEVANT PROJECTS

PROJECT	TITLE	PAGE
BEMP 14-1	Broad whitefish stock differentiation	233
BEMP 14-2	Identification of coregonids	234
BEMP 14-3	Hybridization of coregonids	235
BEMP 14-4	External scarring of whitefish, *Coregonus nasus* and *C. clupeaformis* complex, from the western Northwest Territories, Canada	236
BEMP 14-5	Broad whitefish population dynamics	237
BEMP 14-6	The investigation of food chains and fish migration using the stable isotopes of sulphur, carbon and nitrogen	237
BEMP 15-3	Arctic cisco stock differentiation	245

BEMP HYPOTHESIS NO. 18

AIR EMISSIONS RESULTING FROM THE OPERATION OF AIRCRAFT, MARINE VESSELS, DRILL RIGS, OFFSHORE PLATFORMS AND SHOREBASES WILL ADVERSELY AFFECT AIR QUALITY



- Mobile Sources (Marine and aircraft)
- Drill Rigs
- Offshore Platforms
- Shorebases

LINKAGE

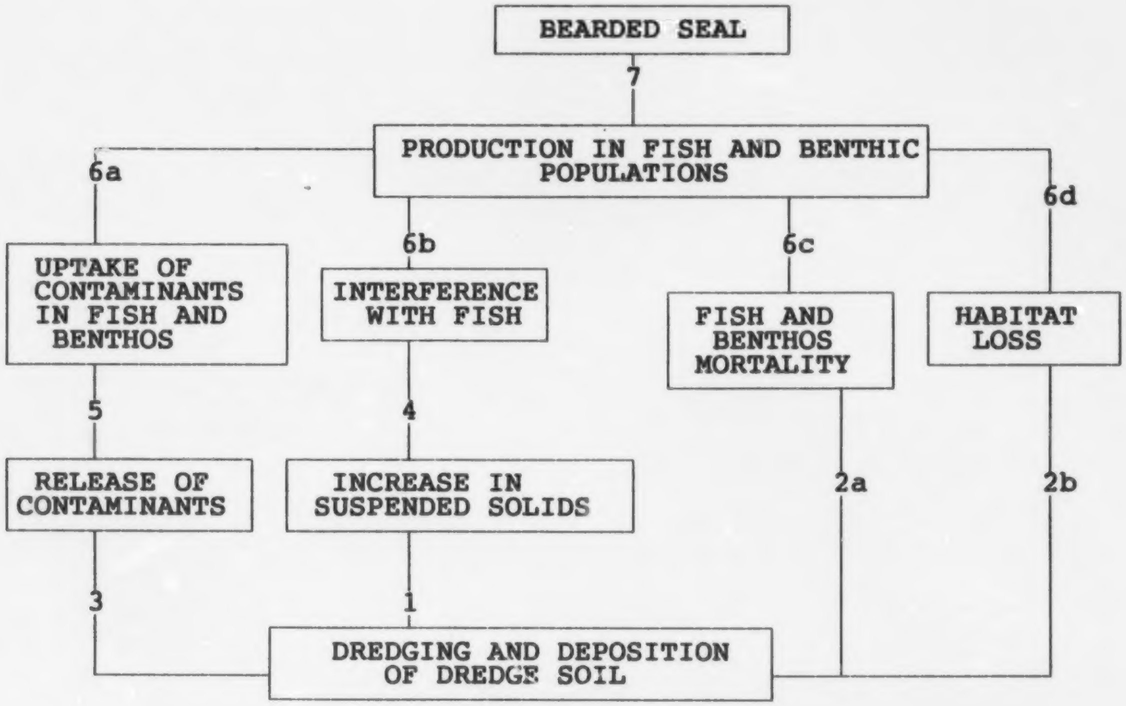
1. Air emissions from a number of sources will adversely affect air quality.

RELEVANT PROJECTS

PROJECT	TITLE	PAGE
—	No other Project Overviews are directly relevant to BEMP Hypothesis No. 18	—

BEMP HYPOTHESIS NO. 19

DREDGING AND DEPOSITION OF SPOILS WILL REDUCE THE BEARDED SEAL POPULATION


BEARDED SEAL
7
PRODUCTION IN FISH AND BENTHIC POPULATIONS
6a
6b
6c
6d
UPTAKE OF CONTAMINANTS IN FISH AND BENTHOS
INTERFERENCE WITH FISH
FISH AND BENTHOS MORTALITY
HABITAT LOSS
5
4
RELEASE OF CONTAMINANTS
INCREASE IN SUSPENDED SOLIDS
2a
2b
3
1
DREDGING AND DEPOSITION OF DREDGE SOIL

LINKAGES

1. Dredging and deposition of dredge spoils will increase concentrations of suspended solids in the water column.
2. Removal of seafloor material and its deposition in other areas will result in mortality of benthic invertebrates and fish and habitat loss.
3. Dredging will release contaminants from the sediments.
4. Increased suspended solids will interfere with fish migration.
5. Contaminants released during dredging will be taken up by fish and benthos.
6. Habitat loss, mortality, interference with migratory routes and uptake of contaminants will reduce fish and benthic invertebrate populations.
7. Reduced populations of prey (fish and benthos) will reduce the number of bearded seals.

RELEVANT PROJECTS

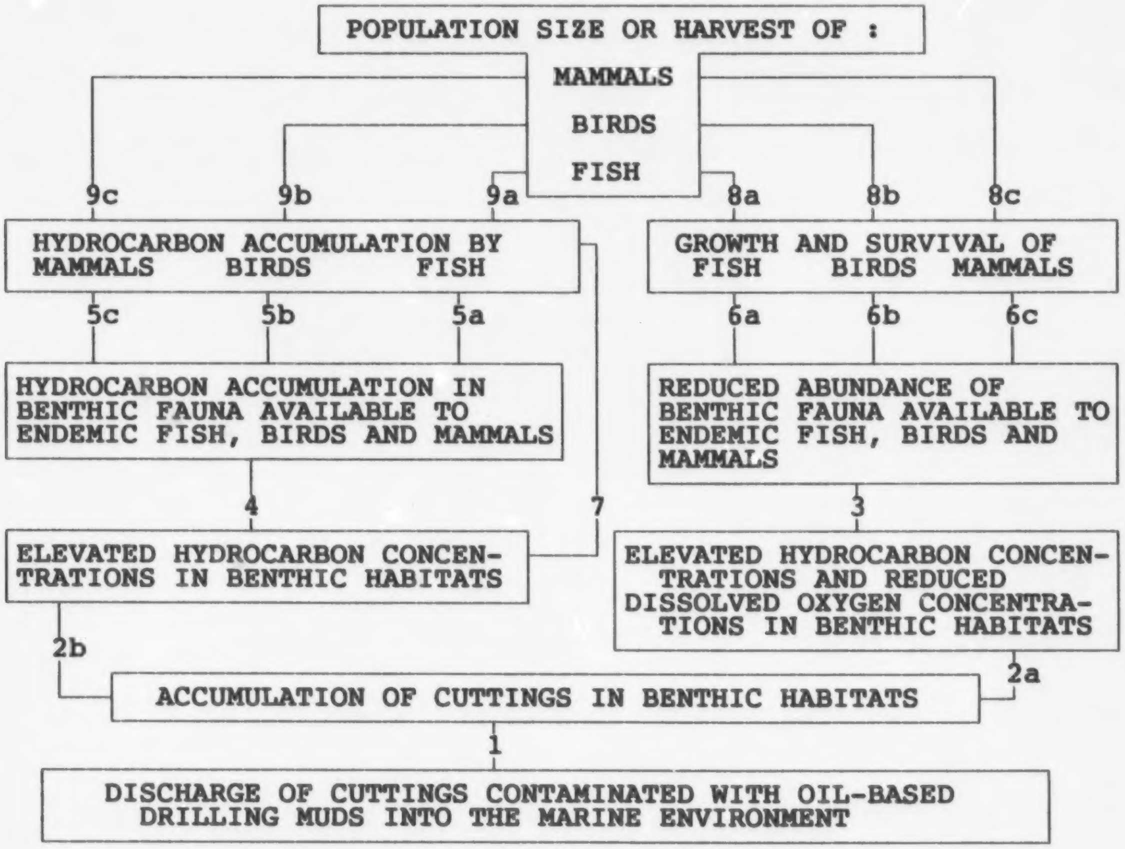
PROJECT	TITLE	PAGE
BEMP 1-1	Beaufort Sea oceanography	85
BEMP 1-26	Effects of offshore petroleum operations on cold water marine mammals: A literature review	128
BEMP 6-2	Mackenzie Shelf fisheries habitat research	164
BEMP 13-2	Nearshore sediment dynamics - Beaufort Sea	208
BEMP 13-3	Beaufort Sea artificial island erosion data	209
BEMP 13-4	Chemical interactions on the Beaufort Sea shelf	210
BEMP 13-7	Geochemistry and fluxes of hydrocarbons to the Beaufort Sea Shelf	214
BEMP 13-8	The distribution of hydrocarbons across the Beaufort Sea Shelf	216

RELEVANT PROJECTS (continued)

PROJECT	TITLE	PAGE
BEMP 13-10	The flux of suspended particulates, petroleum-related hydrocarbons, trace metals and nutrients from the Mackenzie River during the winter season: a pilot study of East Channel	218
BEMP 13-11	Study of the environmental effects of industry staging activities on the marine environment - Year 1	220

BEMP HYPOTHESIS NO. 20

THE DISCHARGE OF DRILL CUTTINGS CONTAMINATED WITH OIL-BASED DRILLING MUDS DURING HYDROCARBON EXPLORATION OR PRODUCTION WILL REDUCE POPULATIONS OF FISH, BIRDS OR MAMMALS OR WILL DECREASE THE HARVEST OF THESE RESOURCES DUE TO HYDROCARBON ACCUMULATION IN TISSUES


POPULATION SIZE OR HARVEST OF :
MAMMALS
BIRDS
FISH
9c
9b
9a
8a
8b
8c
HYDROCARBON ACCUMULATION BY MAMMALS BIRDS FISH
GROWTH AND SURVIVAL OF FISH BIRDS MAMMALS
5c
5b
5a
6a
6b
6c
HYDROCARBON ACCUMULATION IN BENTHIC FAUNA AVAILABLE TO ENDEMIC FISH, BIRDS AND MAMMALS
REDUCED ABUNDANCE OF BENTHIC FAUNA AVAILABLE TO ENDEMIC FISH, BIRDS AND MAMMALS
4
7
3
ELEVATED HYDROCARBON CONCENTRATIONS IN BENTHIC HABITATS
ELEVATED HYDROCARBON CONCENTRATIONS AND REDUCED DISSOLVED OXYGEN CONCENTRATIONS IN BENTHIC HABITATS
2b
2a
ACCUMULATION OF CUTTINGS IN BENTHIC HABITATS
1
DISCHARGE OF CUTTINGS CONTAMINATED WITH OIL-BASED DRILLING MUDS INTO THE MARINE ENVIRONMENT

LINKAGES

1. Drill cuttings contaminated with oil-based drilling muds and discharges during exploration or development drilling will settle rapidly to the seafloor and resist subsequent widespread dispersion due to the cohesiveness of oil-based mud/cuttings mixtures.

2a. In areas of cuttings accumulation, elevated hydrocarbon concentrations will occur in benthic habitats.

2b. In areas of cuttings accumulation, elevated hydrocarbon concentrations and reduced dissolved oxygen concentrations will occur in benthic habitats during the slow degradation of oil-based muds adhering to drill cuttings.

3. The abundance of benthic fauna available to endemic fish, birds and mammals will be reduced in areas of mud/cuttings accumulation due to smothering, oxygen depletion and toxicity of petroleum hydrocarbons in drilling muds or the products resulting from their degradation.

4. Benthic fauna available to endemic fish, birds and mammals in habitats containing mud/cuttings mixtures will accumulate petroleum hydrocarbons.

5a. Decreased abundance of benthic fauna will affect the growth and survival of birds that feed on benthic prey organisms.

5b. Decreased abundance of benthic fauna will affect the growth and survival of birds that feed on benthic prey organisms.

5c. Decreased abundance of benthic fauna will affect the growth and survival of marine mammals that feed on benthic prey organisms.

6a. Marine and anadromous fish will accumulate petroleum hydrocarbons from ingestion of contaminated prey.

6b. Birds will accumulate petroleum hydrocarbons from ingestion of contaminated prey.

6c. Marine mammals will accumulate petroleum hydrocarbons from ingestion of contaminated prey.

7. Marine and anadromous fish remaining in areas containing oil-contaminated cuttings will accumulate petroleum hydrocarbons directly.

8a. The size of marine and anadromous fish populations will be reduced due to local effects of reduced prey availability on growth and survival.

Oil-based Drilling Muds: Off Structure Monitoring Beaufort Sea, Minuk I-53 and Kaubvik I-43

BREAM PROJECT OVERVIEW NO. B20-1

PRINCIPALS INVESTIGATORS:	P. Erickson, B. Fowler and D. Thomas
AFFILIATION:	Arctic Laboratories Limited
FUNDING SOURCE:	ESRF
COMPLETION DATE:	Complete
RELEVANT HYPOTHESIS NO:	BEMP 20

BRIEF PROJECT DESCRIPTION

The fate of low aromatic content base oil (Vista ODC) discharged from two artificial island exploratory well sites in the Beaufort Sea drilled by Esso Resources Canada Limited was studied over a two-year period. Oiled cuttings were discharged during the winter at both locations.

At Minuk I-53, a sacrificial beach island in 14 m of water, base oil could not be detected in surface sediments outside of an extensive area of grounded ice rubble surrounding the island immediately after drill prior to ice break-up. Vista oil was widely dispersed in surface sediments at the end of the following open-water season, as delineated by a distinctive signature of low molecular weight isoprenoids in the GC trace. Most of the oil was dispersed around the south side of the island from the discharge point on the west side and thence in an easterly direction coinciding with the direction of net current flow in the area. Base oil could be reliably quantified more than 700 m to the east of the island. The maximum concentration of Vista ODC (defined in terms of the sum of 10 low molecular weight isoprenoid peaks in the GC trace of Vista) in all samples collected was more than 4000 ug/g at a location 350 m to the southeast of the island centre.

Dispersal of oil-based muds appears to be enhanced by the presence of grounded ice rubble near a sacrificial beach island. Grounded ice restricts dispersion in the winter but can carry oiled cuttings long distances from the island after ice break-up. Less than 12% of the oil discharged at Minuk could be accounted for on the basis of the distribution of oil in surface sediments within 1 km of the island centre at the end of one open-water season following the discharge. It is speculated that most of the oil that has been lost was either buried as a result of erosion of the island or was carried beyond the limits of the study area, likely via ice scour and ice transport.

Dispersion was more restricted at Kaubvik I-43, a caisson retained island in 19 m of water. Oiled cuttings were dispersed in an east-west orientation from the discharge point on the south side of the island. Highest (2000 ug/g) concentrations were to the west in the direction of net residual current flow, with quantifiable base oil present more than 400 m in that direction. The maximum concentration of Vista observed was 2000 ug/g. However, less than 2% of the oil discharged at Kaubvik was present in surficial sediments on the basis of contour plots of surface sediment concentrations. It is not known whether the remaining oil is associated with a cuttings pile on the berm slope or whether it was carried away with drifting ice during the early winter.

Assuming that the oil is associated with an unsampled cuttings pile, the fate of oiled cuttings discharged from a caisson retained island appears to be governed mainly by currents and in this respect is more typical of conventional drilling platforms in more temperate seas.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study provides a good basis for evaluating Links 1 and 2 of BEMP Hypothesis No. 20, as well as the fate of cutting contaminated with oil-based mud in nearshore Beaufort Sea depositional environments. This study provides baseline information for possible future investigations into the persistence of discharged cuttings in the marine environment. Information on the accumulation of the cuttings and their subsequent dispersal and redistribution in the benthic environment will be essential in assessing the possible effects of these discharges on populations of fish, birds and mammals in the region.

REFERENCE

Erickson, P., B. Fowler and D. Thomas. 1988. Oil-based drilling muds: Offstructure monitoring Beaufort Sea, Minuk I-53 and Kaubvik I-43. Environmental Studies Research Funds Report No. 101. 192 p.

Hydrocarbon Effects on Capelin Eggs and Larvae (PERD No. 67227)

BREAM PROJECT OVERVIEW NO. B20-2

PRINCIPAL INVESTIGATORS:	B. Nakashima and J. Carscadden
AFFILIATION:	Department of Fisheries and Oceans, Bedford Institute of Oceanography
FUNDING SOURCE:	PERD
COMPLETION DATE:	Unknown
RELEVANT HYPOTHESIS NO:	BEMP 20 Future impact hypotheses dealing with oil spills

BRIEF PROJECT DESCRIPTION

The objectives of this study are to quantify the effects of oil dosage and exposure conditions on the survival of egg and larval stages of capelin.

In-situ beach monitoring of wave energy and sediment mixing was initiated at Bryant's Cove, Conception Bay, Newfoundland on June 6, 1989 and continued to August 1989. *In-situ* wave energy was measured using 3 high-precision 0-10 psi pressure transducers mounted at depths between 2 and 34 m in the subtidal region. The transducers provided wave height and frequency data at 1 Hz continuously. All data were stored directly on a land-based data logger. Water temperature was simultaneously measured using transmitting thermistor probes and a recording Ryan thermograph.

Wind speed and direction were observed and recorded daily, as were wave, height, wave angle, wave period, breaking distance, maximum run up, and minimum run up. Physical characteristics and changes of the beach were also recorded. Thermometer temperature readings and a photograph of the beach were taken each day. The collected data were stored on computer and back-up copies were made. Data are now being examined for noise spikes and are being cleaned in preparation for analysis. Hourly wind data for the wave monitoring period (taken from St. John's airport) have been logged on the computer for analysis with the wave data. Wind speed and direction were broken down into a longshore and cross-shore component.

An array of sediment-mixing experiments were conducted in the low-, mid-, and high-tide regions of the intertidal immediately landward of the pressure transducer array. Mixing experiments were concentrated on the daily sequential depth of disturbance in the 3 intertidal zones using calibrated beach rods, variable rod and ringed washers, and beach chains. Special consideration was given to periods of on-shore wind events when sediment mixing was greatest. The amount and time of capelin spawning was observed qualitatively. Depth of capelin eggs and larvae in the sediments was determined in parallel to the depth of disturbance measurements. Core samples were taken on a twice-weekly basis and were supplemented by pre- and post-event core samples. These are now being sorted for eggs and larvae, as well as grain size spectra.

Approximately 5 tonnes of beach sediments were imported to Dalhousie from Coley's Point beach for use in the wave tank. These sediments have been used to construct a beach in the wave tank according to the profile measured at Bryant's Cove. Wave experiments are now underway. To determine the dimensions of the beach, the maximum depth of disturbance findings were used. The model beach used inside the tank is being constructed with energy absorptive material behind and under the beach to ensure limited wave reflection. Hibernia crude oil will be used for the wave tank experiments.

Core samples from Bryant's Cove, as well as other beaches in the area, have been collected. Sorting of these samples is currently underway. A final project report is due sometime in April 1991.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

Results of this study are of relevance to Link 7 of BEMP Hypothesis No. 20. Although this research is directed at capelin (present in possibly large numbers but with sporadic distribution in the southern Beaufort Sea), the experimental techniques developed and the results will have broad application to oil and gas development in the context of BREAM.

The Effect of Suspended Sediments and Dispersants on Bacterial Floc Development and *in situ* Oil Degradation

BREAM PROJECT OVERVIEW NO. B20-3

PRINCIPAL INVESTIGATORS:	S. Severin[1] and M.C. Hamilton[2]
AFFILIATIONS:	[1]CBR International and [2]Seakem Oceanography Ltd.
FUNDING SOURCE:	PERD
EXPECTED COMPLETION DATE:	1991
RELEVANT HYPOTHESIS NO.:	BEMP 20

BRIEF PROJECT DESCRIPTION

This multi-year experimental project is aimed at studying the relationship between the presence of marine floc material and the microbial processing of hydrocarbons by marine microorganisms. The specific objectives of the study are to: (1) create an inexpensive portable mesocosm that is sufficiently complex and robust so as to allow investigators to mimic a wide variety of environmental conditions; (2) produce a set of procedures that can be used routinely by environmental investigators to monitor the biological, chemical and physical parameters in the mesocosm, primarily the development of methodologies appropriate for the degradation of complex hydrocarbons such as oil; and (3) assess the ability of natural microbial populations to modify and degrade complex mixtures of hydrocarbons. The experimental aspects of this study concentrate on the effects of dispersants and sediment intrusion on the degradation of Amauligak crude oil by native microbial populations.

The specific hypotheses being tested are as follows.

(1) The presence of suspended sediments will cause an acceleration in the rate of the biological degradation of oil.

(2) The presence of suspended sediments will cause a shortened lag phase prior to the commencement of biodegradation.

The complete oil degradation process is being examined by taking measurements on the isotopically-labelled aliphatic and aromatic hydrocarbon fractions of the flocs and examining the flocs using electron microscopy. The biodegradation of hydrocarbons in oil dispersed with Enersperse 700 is also being studied and compared to the result with Corexit 9527.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

The results of this study will provide information on the biochemical fate of oil in the Beaufort Sea, the role of particulates in changing the rate of degradation, and the effect of dispersants on degradation. It may also provide valuable protocols for future mesocosm-based research into oil degradation.

Effects of Oil-based Mud Cuttings on Fish Larvae

BREAM PROJECT OVERVIEW NO. B20-4

PRINCIPAL INVESTIGATOR:	J.F. Payne
AFFILIATION:	Department of Fisheries and Oceans
FUNDING SOURCE:	PERD
COMPLETION DATE:	1991
RELEVANT HYPOTHESIS NO.:	BEMP 20

BRIEF PROJECT DESCRIPTION

Yoke-sac stage capelin larvae were exposed to oil-based mud cuttings from Minuk. In the first set of experiments, cuttings were mixed in various proportions (1/5 to 1/640) with clean beach sand. In the second group of experiments, dilutions (1/5 to 1/625) of the water soluble portions of the cuttings were used.

The results of the sediment exposures indicated than an increase in larval mortality occurred when larvae were exposed to cuttings concentrations greater than 1/40 for 48 hours. There was not as great an effect in the water-dilution experiments, although slightly more larvae died consistently at a 1/5 dilution. Histological studies indicated that there was no difference between exposed and unexposed larvae.

RELATIONSHIP AND RELEVANCE TO BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This information is relevant to Link 6 of BEMP Hypothesis No. 20, the possible effect of hydrocarbons on the growth and survival of fish. Although the studies were not carried out on arctic fish species, the use of capelin is probably a good surrogate for sensitive early life stages. The preliminary results indicate that effects are clearly possible but that they would be confined largely to the area within a few 100 metres of where oiled cuttings are released due to dilution effects in the receiving environment.

Delineation of Toxic Zones for Fish around Oil Rig Sites: A Long-term Toxicity Study with Winter Flounder

BREAM PROJECT OVERVIEW NO. B20-5

PRINCIPAL INVESTIGATORS:	J.F. Payne and J. Kiceniuk
AFFILIATION:	Department of Fisheries and Oceans
FUNDING SOURCE:	PERD
COMPLETION DATE:	Complete
RELEVANT HYPOTHESIS NO.:	BEMP 20

BRIEF PROJECT DESCRIPTION

The purpose of this experimental study was to evaluate the subchronic toxicity potential of oil-based drill muds to fish. Dose-response relationships were evaluated for a variety of biological and biochemical indices, with winter flounder exposed to sediments contaminated with a mixture of Minuk and Conoco cuttings for approximately 2.5 months to simulate exposure conditions beyond the high impact zone adjacent to the rig site/discharge point.

The content of oil in cuttings was approximately 5%, and the highest concentration of hydrocarbons to which the fish were exposed was in the several thousand ppm range. The indices investigated were biologically meaningful, and included muscle and liver levels of energy reserves, organ-body weight relationships, general condition indices, ion-balance, blood parameters, detoxification enzymes, and liver/gill histopathology.

Exposure did not affect any of the parameters measured. No evidence for dose-response relationship was found.

RELATIONSHIP AND RELEVANCE TO BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

The results of this study indicate that the risk of long-term effects on fish from exposure to oil-based mud cuttings around drill sites is probably negligible except, perhaps, in the area of the immediate cuttings pile.

Hydrocarbon Stress in Juvenile Fish

BREAM PROJECT OVERVIEW NO. B20-6

PRINCIPAL INVESTIGATORS:	J.H. Vandermeulen
AFFILIATION:	Department of Fisheries and Oceans
FUNDING SOURCE:	PERD
COMPLETION DATE:	1991
RELEVANT HYPOTHESIS NO.:	BEMP 20 Future impact hypotheses dealing with oil spills

BRIEF PROJECT DESCRIPTION

The objective of this experimental study is to evaluate the stress imposed on juvenile salmon by exposure to hydrocarbons. This involves the cytological documentation of tissue abnormalities in juvenile salmon from short- and long-term (chronic) exposure studies.

RELATIONSHIP AND RELEVANCE TO BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

The results of this study will provide information on the possible health effects of hydrocarbon exposure and their implications on growth and survival of juvenile fish.

The Effects of Oil Exposure on Juvenile Salmon and their Survival to Adults: An Exposure, Tag, Release and Recapture experiment

BREAM PROJECT OVERVIEW NO. B20-7

PRINCIPAL INVESTIGATORS:	I. Birtwell and C.D. McAllister
AFFILIATION:	Department of Fisheries and Oceans
FUNDING SOURCE:	PERD
EXPECTED COMPLETION DATE:	1992
RELEVANT HYPOTHESIS NO.:	BEMP 20 Future impact hypotheses dealing with oil spills

BRIEF PROJECT DESCRIPTION

This experiment involves exposing 30,000 pink salmon juveniles to different concentrations of the water-soluble fraction of Prudhoe Bay Crude oil for 10 days, tagging the fish and releasing them (with similarly-handled but unexposed control populations) to the environment. Prior to the release, the health of the fish in each treatment is assessed (disease, MFO activity, histopathology). Returns of the marked adult fish to natal streams will generate information that integrates not only the effect of the exposures but also the fitness of the fish in coping with the challenges normally encountered during a salmon's life cycle.

RELATIONSHIP AND RELEVANCE TO BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study will provide some insight into the possible effects at the population level of exposure of fish to hydrocarbons during an early and sensitive life stage. This would simulate levels and duration of exposure possible during a large oil spill in the Beaufort Sea. The use of salmon in this study is a reasonabie surrogate for important anadromous fish species of the Beaufort Region. Results can be used to hindcast and predict the effects of spilled oil on important harvested species.

OTHER RELEVANT PROJECTS

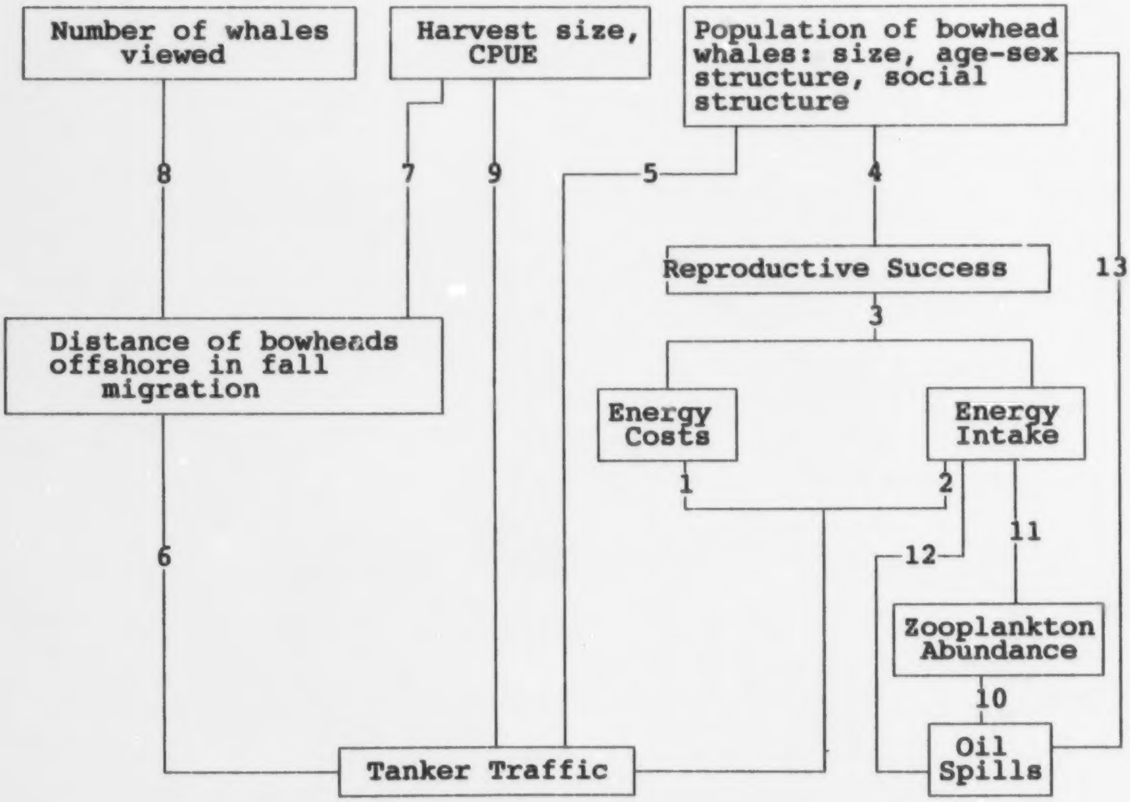
PROJECT	TITLE	PAGE
BEMP 1-1	Beaufort Sea Oceanography	85
BEMP 1-3	The distribution of nutrients in the southeastern Beaufort Sea: implications for water circulation and primary production	87
BEMP 1-4	Production studies in the Mackenzie River-Beaufort Sea estuary	88
BEMP 1-5	Ecological factors governing the distribution and abundance of the copepod, *Limnocalanus macrurus*, in the Beaufort Sea	90
BEMP 1-6	Zooplankton and bowhead whale feeding in the Canadian Beaufort Sea, 1986	92
BEMP 1-7	Zooplankton of a bowhead whale feeding area off the Yukon coast in August 1986	94
BEMP 1-10	Zooplankton distributions in the southeastern Beaufort Sea, summer 1987	99
BEMP 1-11	Distribution and life history of *Limnocalanus macrurus*, an estuarine copepod, in the Beaufort Sea	101
BEMP 1-26	Effects of offshore petroleum operations on cold water marine mammals: A literature review	128
BEMP 10-1	Nearshore sediment transport and dynamics	176
BEMP 13-7	Geochemistry and fluxes of hydrocarbons to the Beaufort Sea Shelf	214
BEMP 13-8	The distribution of hydrocarbons across the Beaufort Sea Shelf	216
BEMP 13-10	The flux of suspended particulates, petroleum-related hydrocarbons, trace metals and nutrients from the Mackenzie River during the winter season: a pilot study of the East Channel	218
BEMP 13-11	Study of the environmental effects of industry staging activities on the marine environment	220

OTHER RELEVANT PROJECTS (continued)

PROJECT	TITLE	PAGE
BEMP 13-12	The Tuktoyaktuk Harbour benthic biological monitoring programme	220
BEMP 13-13	MFO induction measurement	222
BEMP 13-14	Condensate effects on commercial species	225
BEMP 13-15	The evaluation and selection of an analytical method to detect a hydrocarbon taint in fish	227
BEMP 13-16	Tainting/contamination potential of weathered oil particulates for commercially-important fish species	228

BEMP HYPOTHESIS NO. 21

TANKER TRAFFIC AND MINOR OIL SPILLS ASSOCIATED WITH THE WESTWARD TRANSPORT OF CANADIAN BEAUFORT OIL WILL CAUSE REDUCTIONS IN THE WESTERN ARCTIC POPULATION OF BOWHEAD WHALES AND/OR THE HARVEST OF THIS POPULATION BY ALASKAN INUPIAT



LINKAGES

1. Tanker traffic will affect the energy balance of whales by increasing the amount of energy expended over the course of a year.
2. Tanker traffic will lead to a reduction in the energy intake of bowheads by reducing the time available for feeding.
3. The energy balance of a bowhead whale determines its survival and its ability to reproduce.
4. A decrease in reproductive success will lead to a reduction in population size.
5. Tanker traffic will affect the bowhead population through direct mortality, disruption of social behaviour, and separation of cows and calves.
6. Tanker traffic will cause a long-term offshore displacement of the fall migration of bowheads off Alaska.
7. Offshore displacement of the bowhead migration will cause a reduction in the harvest size and catch per unit effort (CPUE) in the fall hunt of bowheads by Alaskan Inupiat.
8. Offshore displacement of the bowhead migration will cause a reduction in the number of whales that can be viewed from shore.
9. Tanker traffic will be perceived by Alaskan Inupiat whalers to have a negative effect on the success of the fall hunt for bowheads.
10. Oil spills associated with tanker loading and unloading will reduce zooplankton abundance.
11. Reduced zooplankton abundance will decrease the energy intake of bowhead whales.
12. Oil spills will decrease the ability of bowhead whales to feed.
13. Oil spills related to tanker transport will directly reduce the size of the bowhead whale population.

RELEVANT PROJECTS

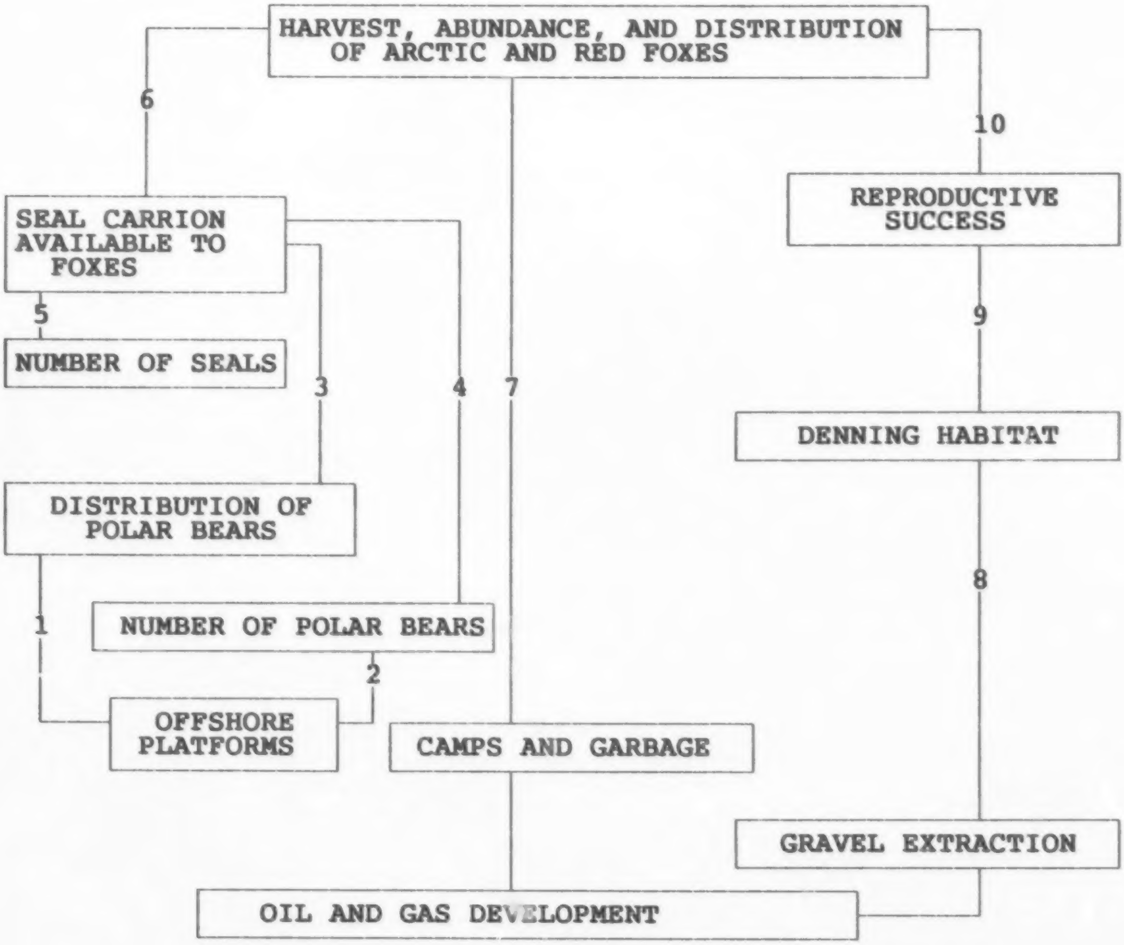
PROJECT	TITLE	PAGE
BEMP 1-17	The potential effects of tanker traffic on the bowhead whale in the Beaufort Sea	112
BEMP 1-22	Movements and behaviours of bowhead whales in response to repeated exposures to noises associated with industrial activities in the Beaufort Sea	122
BEMP 1-23	Movements and behaviours of bowhead whales	123
BEMP 1-25	Analysis and ranking of the acoustic disturbance potential of petroleum industry activities and other sources of noise in the environment of marine mammals in Alaska	126
BEMP 1-26	Effects of offshore petroleum operations on cold water marine mammals: A literature review	128
BEMP 1-27	Effects of noise on marine mammals	130

5.2 RESEARCH RELEVANT TO MEMP HYPOTHESES

The following lists all of the MEMP impact hypotheses and their linkages as they were presented in the 1985-1986 MEMP report (LGL *et al*. 1986). It also includes a discussion of the major findings of research and its relevance to BREAM. Each of the studies are described following the hypothesis to which it is most relevant. In cases where research is relevant to more than one hypothesis, cross referencing has been used. Research described in the previous section that is relevant to both existing BEMP and MEMP hypotheses is also cross-referenced in "Other Relevant Projects" tables.

MEMP HYPOTHESIS NO. 1

THE PRESENCE OF OFFSHORE DRILLING PLATFORMS, CONSTRUCTION CAMPS (AND ASSOCIATED GARBAGE) AND GRAVEL EXTRACTION WILL RESULT IN A DECREASE IN THE NUMBERS OF ARCTIC AND RED FOXES



LINKAGES

1. Polar bears that encounter offshore platforms will subsequently be attracted to these facilities.
2. Polar bears that approach offshore structures have to be controlled, and this will result in the need to destroy some bears.
3. Changes in the distribution of polar bears will alter the distribution of seal carrion on the ice.
4. A decrease in the number of polar bears will reduce the amount of seal carrion on the ice.
5. A decrease in the number of seals due to offshore activities will reduce the amount of seal carrion.
6. A decrease in the amount and change in the distribution of seal carrion will decrease the number of Arctic foxes.
7. The presence of camps and refuse will affect the abundance and distribution of Arctic and red foxes.
8. Gravel extraction activities will decrease the amount of denning habitat.
9. A decrease in the amount of denning habitat will reduce the reproductive success of Arctic and red foxes.
10. Reproductive success influences the abundance and distribution of foxes.

Successful Plant Colonizers on Disturbances in Tundra Areas of Northwestern Canada

BREAM PROJECT OVERVIEW NO. M1-1

PRINCIPAL INVESTIGATOR:	P. Kershaw
AFFILIATION:	Department of Geography, University of Alberta
FUNDING SOURCE:	Boreal Institute of Northern Studies, AINA, The National Wildlife Federation, University of Alberta, and Government of Yukon Territory, Highways Branch.
COMPLETION DATE:	Complete
RELEVANT HYPOTHESIS NO.:	MEMP 1, 5 and 6

BRIEF PROJECT DESCRIPTION

Plant colonization of abandoned borrow pits located in tundra areas, associated with the CANOL Project (1942 to 1945) and the Dempster Highway (1961 to 1979) was studied 32 to 37 and 5 to 22 years following disturbance, respectively.

A total of 433 plant species had colonized borrow pits of the Dempster Highway and CANOL Project corridor. Although the CANOL Project and the Dempster Highway corridors are widely separated and pass through different mountain ranges, 58 plant species were found to have colonized borrow pits in both corridors. These included 39 vascular plant species, 16 lichens, and 3 mosses. Species that were especially successful in both regions included *Arctagrostis latifolia, Betula glandulosa, Equisetum arvense, E. variegatum, Juncus balticus, Luzula parviflora, Salix alaxensis. S. glauca, S. planifolia, S. reticulata, Trisetum spicatum, Cladonia cariosa, Peltigera aphthosa, Psoroma hypnorum, Stereocaulon tomentosum, and Polytrichum piliferum.* Several taxa were more successful in one corridor than in the other. In the CANOL Project corridor, these included *Antennaria isolepis, A. monocephala, Artemisia arctica, Deschampsia caespitosa, Epilobium latifolium, Hedysarum alpinum, Minuartia arctica, M. biflora, Petasites frigidus, Poa alpina, Polygonum viviparum, Salix arctica, Senecio lugens, Veronica wormskjoldii, Cetraria delisei, C. nivalis, C. pinastri, Pannaria pezizoides, Polytrichum commune*, and *P. juniperinum*. In the Dempster Highway corridor, these included *Poa arctica* and *Salix arbusculoides*.

Mean plant cover values at sites along the Dempster Highway ranged from 8 percent on the youngest (5 to 6 years), most northerly sites to 50 - 75 percent on the older (13 to 22 years), most southerly sites. Mean plant cover values along the CANOL Project corridor ranged from 18 to 30 percent on the north and south sites, respectively. Despite the overall lower percentage of plant cover, diversity and persisting taxa were greater at sites of older disturbances, suggesting that environmental limiting factors are more restrictive or severe in the CANOL Project area.

Shortly after abandonment, *Salix alaxensis* naturally colonized borrow pits throughout these two corridors.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

Information obtained during this study is relevant to those impact hypotheses that deal with the restoration of wildlife habitat (MEMP Hypotheses Nos. 1 and 5). Information is provided on the natural recolonization of man-made disturbances, the rate at which it has occurred in borrow pits, and the most successful species along two different corridors in the BREAM study area. While revegetation of man-made disturbances in the study area are most likely to be assisted, this study identifies species which by their performance have demonstrated their potential for use in assisted reclamation projects.

Physical Characteristics, Terrain Associations and Soil Properties of Arctic Fox Dens in Northern Yukon Territory - Final Report

BREAM PROJECT OVERVIEW NO. M1-2

PRINCIPAL INVESTIGATORS:	C.M.M. Smits[1], C.A.S. Smith[2], and B.G. Slough[1]
AFFILIATION:	[1]Yukon Fish and Wildlife Branch and [2]Agriculture Canada
FUNDING SOURCE:	Yukon Department of Renewable Resources, NOGAP
COMPLETION DATE:	Complete
RELEVANT HYPOTHESIS NO.:	MEMP 1

BRIEF PROJECT DESCRIPTION

This study examined physical and soil characteristics of Arctic fox dens on Herschel Island and the Yukon Coastal Plain. Distinct differences in preferred den sites were noted between Herschel Island and the Yukon Coastal Plain. In the former location, denning most commonly occurred in moderately-eroded, sloping, gullied terrain where foxes selected erosional mounds for denning. In the latter region, denning was most common in stream cutbanks and occasional dunes. In general, dens were associated with relatively warm, well-drained sites, predominated by sandy loam to sandy soils.

Den distributions were evaluated using a 1:25,000 soil and vegetation map for Herschel Island and a 1:125,000 surficial deposits and landform map for the Yukon Coastal Plain. The strong association of den sites with specific landforms allows the use of biophysical mapping techniques to classify the potential capability of landscapes for fox denning. Land capability classifications can be utilized in future land use planning to preserve high capability denning habitat in priority areas. Denning capability maps are provided for Herschel Island and the Yukon Coastal Plain.

(Note: a shorter version of this document, without the land capability maps, was published in Arctic 41: 12-16).

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL AND ASSESSMENT MONITORING PROJECT

Link 8 of MEMP Hypothesis No. 1 states that "Gravel extraction activities will decrease the amount of denning habitat". Although information from this land capability study is specific to Herschel Island and the Yukon coastal plain where gravel extraction is unlikely to occur, it provides an approach and data base that could be applied to land capability classification for Arctic fox denning in the outer fringe of the Mackenzie delta and the Beaufort Sea coastline. A similar approach could be developed for classification of red fox denning habitat.

Abundance and Summer Occupancy of Arctic Fox Dens in Northern Yukon Territory 1984-1988

BREAM PROJECT OVERVIEW NO. M1-3

PRINCIPAL INVESTIGATORS: C.M.M. Smits[1], B.G.Slough[1] and A. Angerbjorn[2]
AFFILIATION: [1]Yukon Fish and Wildlife Branch and [2]University of Stockholm
FUNDING SOURCE: NOGAP and Yukon Department of Renewable Resources
COMPLETION DATE: Complete
RELEVANT HYPOTHESIS NO.: MEMP 1

BRIEF PROJECT DESCRIPTION

During aerial surveys conducted in 1984 and 1988, information was obtained on the distribution and occupancy rate of Arctic fox and red fox dens on the Yukon North Slope. Herschel Island supported one of the highest densities of natal dens reported for Arctic fox, whereas the Yukon Coastal Plain supported one of the lowest densities. Information suggests that Herschel island is the primary Arctic fox producing area in the Yukon Territory. Because of the clumped distribution of natal dens on the island, the population is at risk to both harvesting and human disturbance. The absence of breeding dens over vast areas of the coastal plain, the continued use of dens sites over long periods of time (hundreds of years), and the use of specific dens as primary litter producing sites, highlights the importance of dens to Arctic fox populations, and the potential that fox populations may be limited by the availability of suitable den sites.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

Link 9 of MEMP Hypothesis No. 1 examines the relationship between the availability of denning habitat and the reproductive success of Arctic and red foxes. Although the study area for this research project is outside of the areas that are likely to be disturbed by gravel extraction, the study results underscore the importance of Arctic fox denning sites in terms of long-term traditional use and reproduction, and the potential that den sites may limit the population size for Arctic fox. Should future development plans for the Mackenzie delta and the eastern Beaufort Sea coastline require land disturbances in well-drained sites, the need to minimize disturbances to Arctic fox dens must be seriously considered.

Vegetation Mapping of the Yukon Coastal Plain using Landsat Thematic Mapper Imagery

BREAM PROJECT OVERVIEW NO. M1-4

PRINCIPAL INVESTIGATOR:	J.S. Hawkings
AFFILIATION:	Canadian Wildlife Service, Yukon
FUNDING SOURCE:	Inuvialuit Final Agreement, NOGAP, Yukon Dep. Renewable Resources and CWS
COMPLETION DATE:	1990
RELEVANT HYPOTHESES NO.:	MEMP 1-11

BRIEF PROJECT DESCRIPTION

Vegetation cover is being mapped in a 3000-4000 km^2 area of low arctic tundra on the Yukon costal plain between the Firth River and the Yukon/Northwest Territories border. This is an area rich in wetlands and important to wildlife, especially caribou (with a small population of moose, an expanding population of muskox, and populations of grizzly bear, wolf, Arctic fox and wolverine) and migratory birds, especially waterfowl (and in particular lesser snow geese), shorebirds and other waterbirds such as loons and jaegers. The primary purpose of the project is to delineate vegetation/landform units at a scale 1:100,000 which are relevant to wildlife. The final maps are expected to contain 15 to 20 vegetation classes. Particular areas of interest are polygons, which are proving to be a challenge, and mosses, which may not only be more diverse than the vascular component of the vegetation, but may also be of greater ecological significance.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

The above study has relevance to all of the hypotheses involving the effects of hydrocarbon development on wildlife in the Beaufort region in that valuable data are being gathered as a baseline for future studies on populations of wildlife in the area after hydrocarbon development has been established. Development effects on the vegetation (gravel extraction, seismic exploration, construction of roads, camps and pipelines, general habitat alterations and oil spills on beaches) will lead to effects on the wildlife feeding, nesting or staging in those areas affected, and ongoing LANDSAT mapping projects will monitor any changes in the vegetation regime.

REFERENCE

Hawkings, J.S., D.R. Jaques and B.A. Hawkings. 1990. Vegetation mapping of the Yukon Coastal plain using landsat thematic mapper imagery. Draft MS by CWS, Yukon, ECOSAT Geobotanical Surveys, B.C. and Fish and Wildlife Branch, Yukon Dep. Renewable Resources, Whitehorse. 4 p.

Native Harvest Surveys and Statistics: A Critique of their Construction and Use

BREAM PROJECT OVERVIEW NO. M1-5

PRINCIPAL INVESTIGATORS:	P.J. Usher[1] and G. Wenzel[2]
AFFILIATIONS:	[1]P.J. Usher Consulting Services and [2]The Department of Geography, McGill University
FUNDING SOURCE:	Unknown
COMPLETION DATE:	Complete
RELEVANT HYPOTHESIS NO.:	All hypotheses dealing with harvesting

BRIEF PROJECT DESCRIPTION

This paper reviews and assesses two common sources of native harvest data: administrative and monitoring records, and special-purpose studies. The existing data base was evaluated with particular attention to precision and uniformity of survey parameters and interview terminology, sampling procedures, non-response bias and response bias. The report concluded that the existing data base may be used to recreate an historical statistical series of substantial breadth and depth useful for both biological and socio-economic research purposes.

The report examines the administrative and monitoring record regime in the North from an historical perspective and describes what the record was used for. It also focuses on special-purpose studies including scholarly social science studies, government planning studies, socio-economic impact assessments and claims statements, nutrition studies, and biological and wildlife management studies. Characteristics of harvest data are delineated and the basic parameters for any set of harvest statistics are detailed in terms of harvests, categories of statistics, temporal considerations, space and the harvester. Survey methods are also evaluated, and sampling methods and the manner of treatment for response bias are assessed.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

The report findings are relevant to all impact hypotheses that deal with harvesting. Of particular importance is the use of "traditional knowledge" or user recall in the formulation of the harvest statistic.

REFERENCE

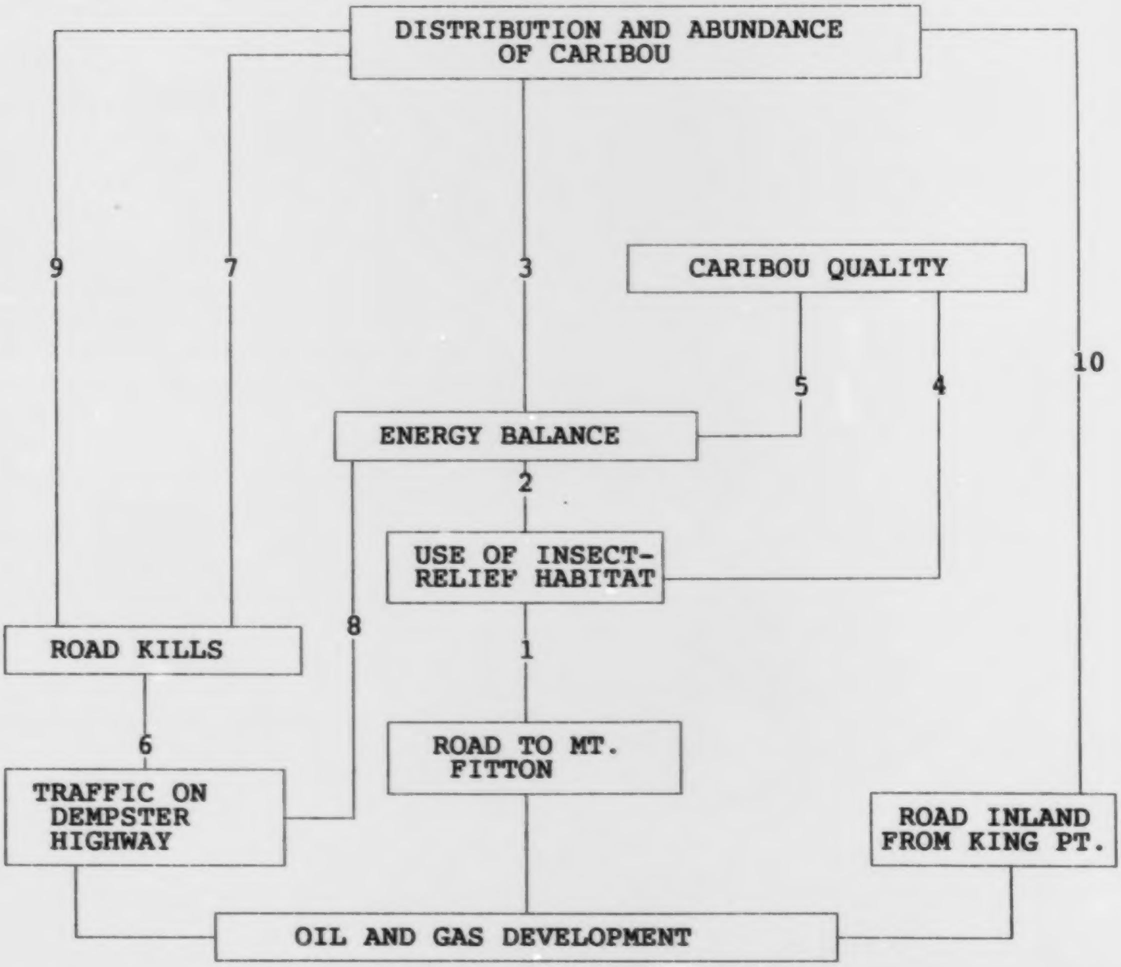
Usher, P.J. and G. Wenzel. 1987. Native harvest surveys and statistics: A critique of their construction and use. Arctic Vol. 40, No. 2. p.145-160.

OTHER RELEVANT PROJECTS

PROJECT	TITLE	PAGE
---	No other Project Overviews are directly relevant to MEMP Hypothesis No. 1	---

MEMP HYPOTHESIS NO. 2

INCREASED TRAFFIC ON THE DEMPSTER HIGHWAY AND ROADS ON THE NORTH SLOPE WILL DECREASE THE NUMBER OF CARIBOU AND ALTER THEIR DISTRIBUTION


DISTRIBUTION AND ABUNDANCE OF CARIBOU
9
7
3
CARIBOU QUALITY
10
5
4
ENERGY BALANCE
2
USE OF INSECT-RELIEF HABITAT
8
ROAD KILLS
1
6
ROAD TO MT. FITTON
TRAFFIC ON DEMPSTER HIGHWAY
ROAD INLAND FROM KING PT.
OIL AND GAS DEVELOPMENT

LINKAGES

1. Traffic on the proposed road inland to Mt. Fitton (or through Blow Pass) could act as a barrier to a large segment of the Porcupine caribou herd and prevent animals from reaching insect-relief areas in the northern Richardson Mountains in late July and early August.

2. Restricted access to insect-relief areas will increase the daily energy requirements associated with insect avoidance, reduce fat storage in the fall and may also result in an increased incidence of parasites in caribou.

3. Lower energy levels will result in decreased calving success, lower calf survival and, therefore, lower numbers of caribou.

4. Reduced access to insect-relief habitat will increase the incidence of parasites and reduce the quality of caribou hides.

5. Decreased animal fat levels will reduce the quality of caribou meat and hides.

6. Increased traffic on the Dempster Highway will increase the number of caribou killed as a result of collisions with vehicles.

7. Road kills on the Dempster Highway will decrease the abundance of caribou.

8. Increased traffic levels on the Dempster Highway will harass caribou and increase energy expenditure.

9. Increased traffic on the Dempster Highway will act as a barrier and prevent access of caribou to habitat south of the highway.

10. Traffic on the proposed road inland from King Point could act as a barrier to the bull/barren cow segment of the herd and force animals to travel a greater distance to reach the large post-calving aggregations of caribou.

Road Dust and its Environmental Impact on Alaskan Taiga and Tundra

BREAM PROJECT OVERVIEW NO. M2-1

PRINCIPAL INVESTIGATOR:	D.A. Walker
AFFILIATION:	Institute of Arctic and Alpine Research, and Department of Environmental, Population and Organismic Biology, University of Colorado, Boulder, Colorado
FUNDING SOURCE:	CRRE and DOE
COMPLETION DATE:	Complete
RELEVANT HYPOTHESIS NO.:	MEMP 2, 3, 7, 8 and of general interest

BRIEF PROJECT DESCRIPTION

The objective of this study was to summarize the physical and chemical characteristics of road dust from the Spine Road and determine its impact on arctic vegetation in the area. Spine Road is a major arterial highway that was constructed in 1974 through the Prudhoe Bay oilfield. It is the most heavily travelled road in northern Alaska.

The study was initiated in 1976. Dust was collected at six sites from paired pans placed up to 1000 m from each side of the road. Seventeen permanent vegetation transects were established along the road. The quadrants, spaced at 1 m intervals along 25 m lines placed normal to both sides of the road, were sampled initially during the summers of 1976 to 1978 and in 1983.

Major findings of this study, which are considered relevant to BREAM, are summarized below.

1. Early snowmelt in roadside areas due to lower albedos resulted in a snow-free band of vegetation within 30 to 100 m of the road, which was used by waterfowl and numerous other species of wildlife. In 1986, concentrations of ptarmigan (numbering in the thousands) were present in these areas, with large flocks commonly sitting on the road. Caribou take advantage of the early snow-free areas for grazing, and grizzly bears, raptors and other predators use these areas to hunt ground squirrels and voles.

2. A decrease in *Sphagnum* and other acidophilous mosses and an increase in many minerotrophic mosses were observed near the road.

3. A decrease in soil lichens, particularly species of *Cladina*, *Peltigera*, and *Stereocaulon* was noted.

4. There was an elimination of corticolous lichens near the road in areas of particularly high dust fall.

5. There was general opening of the ground cover near the road and a consequent colonization of these barren surfaces by many taxa that are common on mineral-rich soils.

6. Few effects on vascular plants were observed, except in areas of very high dust where ericaceous taxa and conifers were affected.

7. There was an increased depth of thaw within 10 m of the road, possibly due to decreased plant cover and earlier initiation of thaw, and this contributed to thermokarst in roadside areas.

RELATIONSHIPS AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This Alaskan study provides relevant information concerning the short-term impacts of road dust on the species composition of nearby vegetation. It identifies lichen woodlands and ambrotrophic bogs as being highly susceptible to dust effects. Further work is required to determine long-term effects. Observations on the effects of early roadside snowmelt on wildlife indicated that temporary alteration in the distribution of several species occurred. This is of direct relevance to MEMP Hypotheses Nos. 1, 2, 3, 7, and 8. The ecological consequences related to permafrost and the melting of ground ice and other consequences related to wildlife have not been fully explored.

Summer Ecology of the Porcupine Caribou Herd in Northern Yukon

BREAM PROJECT OVERVIEW NO. M2-2

PRINCIPAL INVESTIGATORS: D. Russell and W. Nixon
AFFILIATION: Canadian Wildlife Service
FUNDING SOURCE: NOGAP
EXPECTED COMPLETION DATE: Unknown
RELEVANT HYPOTHESIS NO.: MEMP 2

BRIEF PROJECT DESCRIPTION

During 1984 to 1986, an intensive study of the summer range relationships of the Porcupine Caribou herd was undertaken to define and identify critical summer habitat in the Northern Yukon (i.e., north of the treeline) to better predict the potential impacts of human activity on caribou. The study is a comprehensive assessment of caribou behaviour and movements in relation to feeding requirements and insect avoidance. The report is comprised of nine chapters that describe the study purpose and study area, summer movement patterns, vegetation communities, dipteran activity, climate and weather patterns within the summer range, responses of individual caribou to insect harassment, herd responses to insect harassment, and food and habitat selection.

Summer movement patterns of the Porcupine Caribou herd were monitored using a combination of radio-telemetry flights and ground surveys. Based on observations of individual radio-collared animals and larger herds, it is suggested that caribou summer movements are the result of relief from insect harassment (i.e., movements to insect relief habitat) and use of the best feeding areas. It is hypothesized that seasonal movements of the herd reflect the sensitivity of the range to overgrazing and trampling, as well as the separation of the best feeding habitat from insect relief areas. The north flank of the Muskeg basin, the movement corridor to the Richardson Mountains, and the Richardson Mountains were considered to be important habitat for the Porcupine Caribou herd.

The distribution and coverage of vegetation communities of importance to the Porcupine Caribou herd was determined for the area north of the treeline in the Yukon Territory using satellite (Landsat) imagery. Twenty vegetation communities of importance to the Porcupine caribou herd were identified, the majority of which were associated with low shrub and graminoid herbaceous forms of vegetation. Mapping of vegetation communities using Landsat imagery is presently underway. Based on an assessment of the preliminary vegetation maps, it is concluded that the Richardson Mountains is the most favourable foraging habitat for caribou in the Northern Yukon.

The study of mosquito activity focused on the relationships between mosquito activity and weather, and mosquito behaviour and habitat type. Measures of mosquito activity indicated that date was the ultimate factor determining the presence and level of activity of mosquitoes, with mosquito activity peaking in the second week of July and declining thereafter. However, weather (temperature and wind speed) strongly influenced the daily levels of activity.

Assessment of regional weather patterns indicated that much of the summer range of the Porcupine Caribou herd is within an area where warm, moist northeasterly flows from interior Alaska and cool southwesterly flows from the Beaufort Sea interact. The weather patterns in the northern Richardson Mountains and along the south flank of the Barn Range, in combination with information on mosquito activity, indicates that these areas are the least favoured habitats for mosquito, and are therefore strongly favoured by caribou for insect relief and foraging.

Observations of the responses of individual caribou to insect harassment indicate that annoyance responses (e.g., head shaking) increase during the insect season when weather favours dipteran activity. Lying and feeding activity declined, whereas standing behaviour increased. Feeding activity also declined with increases in insect harassment. This latter response may reflect the direct effects of insect harassment, as well as the use of less productive habitats (e.g., sedge/heath, dryas barrens) during periods of high dipteran activity.

Assessment of the behavioural response of caribou to dipteran activity examined the relationships between herd size and insect activity, as well as the advantages and disadvantages of locations within a herd relative to insect harassment. During weather conditions that favoured dipteran activity, caribou tended to form denser groups than during periods of low insect activity. It was also concluded that animals near the core or on the windward side of large (<1,000 animals) herds could gain a small advantage by reducing their exposure to insects.

The concluding chapter of the report integrates the findings of the caribou movement, habitat classification, insect activity, and caribou behaviour research, and discusses the potential impacts of human activity on the energetics of the herd during the summer period. It was concluded that primary insect relief habitat, as well as movement corridors to these areas, must be protected from industrial development. If development is to occur, mitigation measures must ensure that activity budgets of caribou are not altered, herd dynamics are maintained, free movement is not restricted, key habitats are not alienated, and hunting access is not increased. Because of the importance of the Richardson Mountains for insect relief and feeding, is recommended that development in this region be permanently curtailed. Road construction and use through the Richardson Mountains (e.g., Blow Pass) must also ensure that caribou movements are not altered and that hunting activity does not increase.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL AND ASSESSMENT MONITORING PROJECT

The study of the summer range ecology of the Porcupine Caribou herd provides important information for MEMP Hypothesis No. 2, particularly in terms of the importance of insect relief habitat to the summer activity budgets and energetics of caribou. Although information from this study will not alter the validity of the hypothesis linkages (all linkages were previously concluded to be valid), it does provides better documentation for most linkages (particularly Links 1, 2, 4, 9 and 10). Recommendations from this study also provide an excellent basis for planning of mitigation measures for proposed projects within the range of the Porcupine Caribou herd in the Northern Yukon.

Computer Simulation Models of the Porcupine Caribou herd: ENERGY

BREAM PROJECT OVERVIEW NO. 2-3

PRINCIPAL INVESTIGATORS:	L.L. Kremsater[1], F.W. Hovey[1], D.E. Russell[2], R.G. White[3], F.L. Bunnell[1] and A.M. Martell[2]
AFFILIATIONS:	[1]Faculty of Forestry, University of British Columbia, [2]Canadian Wildlife Service, and [3]Institute of Arctic Biology
FUNDING SOURCE:	NOGAP
COMPLETION DATE:	Complete
RELEVANT HYPOTHESIS NO.:	MEMP 2

BRIEF PROJECT DESCRIPTION

The report describes the first of three models, the ENERGY Model, that was developed for the Porcupine Caribou Technical Committee. The model simulates the energy relationships of the Porcupine caribou herd using input variables such as diet composition, biomass of major forage types, nutrient content of forage, and the proportion of the day spent feeding. In combination with a simplified rumen function model (based on hourly iterations), the energy model predicts daily metabolic energy intake for individual caribou on a daily basis. Weaknesses of the ENERGY model are discussed and recommendations for improvement of the model are provided in this report.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

Links 2, 3, 5 and 8 of MEMP Hypothesis No. 2 relate changes in energy levels to calf survival and quality of caribou meat, respectively. The ENERGY Model, in combination with the GROWTH and HARVEST models (see Project Overviews M2-4 and M2-5, respectively) can be used to assess the effects of human activities and developments on the herd demographics over a long period (e.g., 15 years). In the event that the effects of future development scenarios are assessed as part of the BREAM program, these three models could be used to simulate the potential changes in the abundance of caribou.

REFERENCE

Kremsater, L.L., F.W. Hovey, D.E. Russell, R.G. White, F.L. Bunnell and A. M. Martel. 1989. Computer Simulating Models of the Porcupine Caribou herd: Energy. Technical Report Series No. 53, Canadian Wildlife Service, Pacific and Yukon Region, B.C. 14 p. + appendices.

Computer Simulation Models of the Porcupine Caribou herd: GROWTH

BREAM PROJECT OVERVIEW NO. M2-4

PRINCIPAL INVESTIGATORS:	F.W. Hovey[1], L.L. Kremsater[1], R.G. White[3], D.E. Russell[2], and F.L. Bunnell[1]
AFFILIATIONS:	[1]Faculty of Forestry, University of British Columbia, [2]Canadian Wildlife Service, and [3]Institute of Arctic Biology
FUNDING SOURCE:	NOGAP
COMPLETION DATE:	Complete
RELEVANT HYPOTHESIS NO.:	MEMP 2

BRIEF PROJECT DESCRIPTION

The report describes the second of three models, the GROWTH Model, that was developed for the Porcupine Caribou Technical Committee. The model simulates the growth of individual caribou in the Porcupine herd utilizing input variables such as metabolizable energy intake (from the ENERGY model, see Project Overview M2-3), activity budgets and snow depths.

Using output from the ENERGY model, the GROWTH model predicts weight loss and gain throughout an annual cycle. Potential problems in the GROWTH model are also identified in this report.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

Links 2 and 5 of MEMP Hypothesis No. 2 relate changes in energy levels to fat storage and quality of caribou meat, respectively. The GROWTH Model, in combination with the ENERGY and HARVEST models (see Project Overviews M2-3 and M2-5, respectively) can be used to assess the effects of human activities and developments on the herd demographics over a long period (e.g., 15 years). In the event that the effects of future development scenarios are assessed as part of the BREAM program, these three models could be used to simulate the potential changes in the abundance of caribou.

REFERENCE

Hovey, F.W., L.L. Kremsater, R.G. White, D.E. Russell and F.L. Bunnell. 1989. Computer simulation models of the Porcupine Caribou herd: Growth. Technical Report Series No. 54, Canadian Wildlife Service, Pacific and Yukon Region, British Columbia. 16 p. + appendices.

Computer Simulation Models of the Porcupine Caribou herd: HARVEST

BREAM PROJECT OVERVIEW NO. M2-5

PRINCIPAL INVESTIGATORS:	F.W. Hovey[1], D.E. Russell[2], F.L. Bunnell[1], R. Farnell[3], and K.R. Whitten[4]
AFFILIATIONS:	[1]Faculty of Forestry, University of British Columbia, [2]Canadian Wildlife Service, [3]Yukon Department of Renewable Resources, and [4]Alaska Department of Fish and Game
FUNDING SOURCE:	NOGAP
COMPLETION DATE:	Complete
RELEVANT HYPOTHESIS NO.:	MEMP 2

BRIEF PROJECT DESCRIPTION

The report describes the third of three models, the HARVEST Model, that was developed for the Porcupine Caribou Technical Committee. Utilizing input from the ENERGY and GROWTH models (see Project Overviews M2-3 and M2-4, respectively), the model predicts the demographics of the herd over long-time intervals. Population parameters are calculated on an annual basis, whereas population changes are predicted for five-year intervals. Harvesting by 10 native communities and 2 non-native groups, as well as predation (e.g., wolves, grizzly bear and golden eagles) and natural mortality are incorporated into the model. Suggestions for improving the model are also discussed in this report.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

All of the linkages in MEMP Hypothesis No. 2 ultimately lead to changes in the abundance and distribution of caribou. As discussed previously, the HARVEST Model, in combination with the ENERGY and GROWTH models can be used to assess the effects of human activities and developments on the herd demographics over a long period (e.g., 15 years). In the event that the effects of future development scenarios are assessed as part of the BREAM program, these three models could be used to simulate the potential changes in the abundance of caribou.

REFERENCE

Hovey, F.W., D.E. Russell, F.L. Bunnell, R. Farnell and K.R. Whitten. 1989. Computer simulation models of the Porcupine Caribou herd: HARVEST. Technical Report Series No. 55, Canadian Wildlife Service, Pacific and Yukon Region, British Columbia. 10 p. + appendices.

Report on the Caribou Impact Analysis Workshop, Arctic National Wildlife Refuge, November 19-20, 1985

BREAM PROJECT OVERVIEW NO. M2-6

PRINCIPAL INVESTIGATORS:	G.W. Ellison, A.G. Rappoport and G.M. Reid
AFFILIATION:	U.S. Fish and Wildlife Service
FUNDING SOURCE:	Unknown
COMPLETION DATE:	Complete
RELEVANT HYPOTHESIS NO.:	MEMP 2

BRIEF PROJECT DESCRIPTION

The report describes the results of a workshop conducted to assess the potential effects on the Porcupine caribou herd of petroleum development on the coastal plain of the Arctic National Wildlife Refuge. Based on a hypothetical development scenario for petroleum development, the workshop concluded that development would result in a negative effect on the coastal caribou population and their distribution. The greatest concern was for displacement from traditional calving areas, and displacement or restricted access to insect relief habitat. Potential mitigation measures for petroleum development on the coastal plain included permanent closure of the core calving habitat, limiting access to only essential personnel, closure of the region to all hunting (traditional and recreational), design of pipelines to facilitate caribou passage, consolidation of facilities to minimize surface disturbances and noise, and area closures during critical life phases for caribou.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

Although specific details of the workshop cannot be directly extrapolated to summer range use in the Northern Yukon Territory, the overall conclusions support the validation of Links 1, 2, 3, 6, 7, 8, 9, and 10 as presented in the original MEMP workshop. Suggestions for mitigation are also applicable to the Northern Yukon.

REFERENCE

Ellison, G.W., A.G. Rappoport and G.M. Reid. 1986. Report on the caribou impact analysis workshop, Arctic National Wildlife Refuge, November 19-20, 1985. United States Dept. of the Interior, U.S. Fish and Wildlife Service. 39 p.

Caribou Behaviour and Movements in the Kuparuk Oilfield: Implications for Energetic and Impact Analyses

BREAM PROJECT OVERVIEW NO. 2-7

PRINCIPAL INVESTIGATOR:	S.M. Murphy
AFFILIATION:	Alaska Biological Research Inc., Fairbanks, AK
FUNDING SOURCE:	Unknown
COMPLETION DATE:	Complete
RELEVANT HYPOTHESIS NO.:	MEMP 2

BRIEF PROJECT DESCRIPTION

Responses of caribou to oilfield development are discussed in terms of insect harassment, disturbance and energy balance. Corridors that combined elevated pipelines with parallel roadways had the greatest effect on caribou crossing success, activity budgets and rates of movement. Isolated pipelines and roads without pipelines appeared to have much less of a negative effect. Response distances of caribou to pipeline/roadway combinations and isolated pipelines are estimated using comparisons of expected activity budgets and observed activity budgets. Recommendations for future research include assessment of the frequency and duration of caribou with oilfield development, and quantification of habituation to oilfield development.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

Links 1 and 10 of MEMP Hypothesis No. 2 examine the potential for roadways to act as barriers to caribou movements, with particular reference to movements to insect relief areas and staging areas for post-calving aggregations, respectively. The above study provides some quantitative information to validate these linkages, as well as quantify the types of caribou responses to roadways and traffic. In particular, the study results suggest that if vehicular traffic is absent, the presence of roadways may not act as a barrier to directed (migratory) movements of caribou. Seasonal restriction of road use in the Northern Yukon (i.e., during the period when caribou are moving into or through their summer range) may therefore be an effective mitigation method to minimize or avoid direct physical effects on migration.

REFERENCE

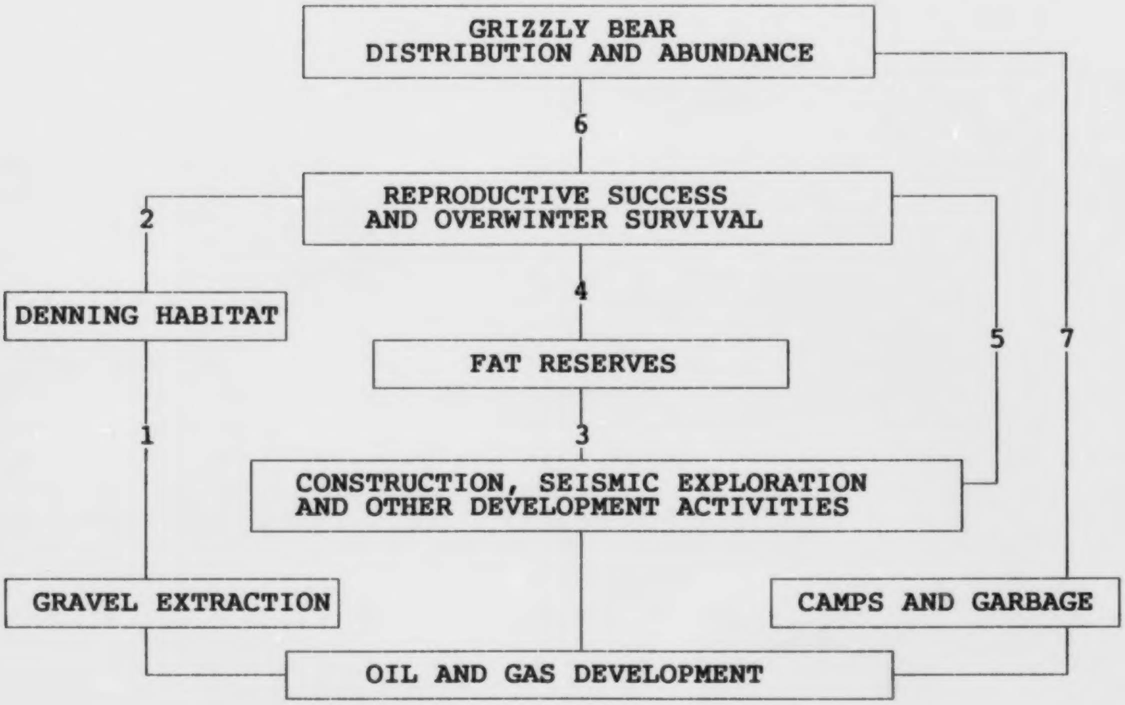
Murphy, S.M. 1988. Caribou behaviour and movements in the Kuparuk Oilfield: Implications for energetics and impact analyses. Pages 196 - 210 *In:* R.D. Cameron and J.L. Davis (ed.). Reproduction and Calf Survival. Proceedings of the Third North American Caribou Workshop. Alaska Dept. Fish and Game. Wildlife Technical Bulletin No. 8.

OTHER RELEVANT PROJECTS

PROJECT	TITLE	PAGE
MEMP 1-4	Vegetation mapping of the Yukon Coastal Plain using Landsat thematic mapper imagery	280

MEMP HYPOTHESIS NO. 3

GRAVEL EXTRACTION, CONSTRUCTION, SEISMIC EXPLORATION AND OTHER DEVELOPMENT ACTIVITIES, AND THE PRESENCE OF CAMPS AND GARBAGE WILL DECREASE THE NUMBER OF GRIZZLY BEARS AND ALTER THEIR DISTRIBUTION


GRIZZLY BEAR DISTRIBUTION AND ABUNDANCE
6
REPRODUCTIVE SUCCESS AND OVERWINTER SURVIVAL
2
4
DENNING HABITAT
5
7
FAT RESERVES
1
3
CONSTRUCTION, SEISMIC EXPLORATION AND OTHER DEVELOPMENT ACTIVITIES
GRAVEL EXTRACTION
CAMPS AND GARBAGE
OIL AND GAS DEVELOPMENT

LINKAGES

1. Gravel extraction will remove denning habitat.

2. A decrease in denning habitat will result in a decrease in reproductive success and overwinter survival.

3. construction and other development activities during late summer may disrupt feeding activity and increase movement of bears, which will result in decreased fat reserves in the fall.

4. Fat reserves determine reproductive success, overwinter survival and quality of the fur.

5. construction, seismic exploration and other development activities during winter may cause bears to abandon their dens, which will reduce overwinter survival and reproductive success.

6. Reproductive success and overwinter survival determine, in part, the size of the grizzly bear population.

7. Grizzly bears that are attracted to camps and garbage may be destroyed as nuisance animals, which will result in a decrease in the grizzly bear population.

Biology and Management of Grizzly Bear on the Yukon North Slope

BREAM PROJECT OVERVIEW NO. M3-1

PRINCIPAL INVESTIGATOR:	J.A. Nagy
AFFILIATION:	Yukon Fish and Wildlife Branch
FUNDING SOURCE:	Department of Renewable Resources, Yukon Territory
COMPLETION DATE:	Complete
RELEVANT HYPOTHESIS NO.:	MEMP 3

BRIEF PROJECT DESCRIPTION

This report provides a compilation of data for grizzly bear populations in the Northern Yukon Territory. Information is provided on population characteristics, home range size and movements, food habitats, and habitat use and, where applicable, is contrasted with information for grizzly bear populations in the southern Yukon, Tuktoyaktuk Peninsula, and the Alaska North Slope. Deficiencies in the existing data base are identified, and research priorities to fulfil these deficiencies are discussed. Methods to determine the harvestable surplus of grizzly bears in the Northern Yukon are reviewed, and estimates of the allowable man-caused mortality for the Northern Yukon are derived using a specific modelling approach (LESMOD). Following a review of the current status of the Northern Yukon grizzly bear population, recommendations for monitoring and regulating the annual harvest are provided.

Much of the information provided in this review is important in understanding the demography of the Northern Yukon grizzly bear population and thereby better understanding the mechanisms and significance of potential effects of development activities. However, the most important aspect of this review in relation to MEMP Hypothesis No. 3 relates to the estimation of the total allowable man-caused mortality (i.e., hunting, accidental deaths, and removal of problem animals) for the Northern Yukon grizzly bear population. Using a population model based on information on the age structure, longevity, birth, sex and mortality rates of bears for the Northern Yukon, different absolute and proportional harvesting rates were applied to estimate acceptable man-caused mortality rates. A conservative maximum harvest mortality of 4 percent of the population was proposed, with a sex ratio of three males to one female in the annual kill. Based on recent population estimates for grizzly bear in the Northern Yukon, the maximum quota should be 5 bears (4 males, 1 female) on territorial lands and 4 bears (3 males, 1 female) in the National Park.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

Link 7 of MEMP Hypothesis No. 3 addresses the potential effects of the destruction of problem animals on the North Slope grizzly bear population. Information utilized in the validation of the linkage was based on estimates of total allowable harvest from a population model for polar bear, as well as information from earlier grizzly bear studies in the Mackenzie Delta and Tuktoyaktuk Peninsula. The information on grizzly bear harvest from the Northern Yukon study supports and corroborates the conclusion that the combined loss of small numbers (i.e., <10) of grizzly bears from hunting and removal of problem animals could result in a gradual decline in the regional population, particularly when losses occur in a year with low production and survival of cubs.

REFERENCE

Nagy, J.A. 1990. Biology and Management of grizzly bears on the Yukon North Slope. Yukon Fish and Wildlife Branch. 68 p.

The Status of the Barren Ground Grizzly Bear in Canada

BREAM PROJECT OVERVIEW NO. M3-2

PRINCIPAL INVESTIGATOR:	M. Bromley
AFFILIATION:	Department of Renewable Resources, N.W.T.
FUNDING SOURCE:	Department of Renewable Resources, N.W.T.
COMPLETION DATE:	Complete
RELEVANT HYPOTHESIS NO.:	MEMP 3

BRIEF PROJECT DESCRIPTION

Information on the barren ground grizzly bear in the Northwest Territories is summarized in this report. With the exception of detailed field surveys on Richards Island and the Tuktoyaktuk Peninsula, no other comprehensive ecological studies of grizzly bear have been conducted in the N.W.T. No new field studies had been conducted or initiated between the completion of the MEMP report in 1986 and the completion of this report (1988).

Information on current grizzly bear management and hunting quotas is reviewed and is of particular significance to the MEMP assessment. As of 1988, the communities of Tuktoyaktuk and Paulatuk have been given a commercial quota of 5 tags each. Paulatuk harvested 2 bears during 1987, whereas Tuktoyaktuk harvested 4 bears during 1986. An increased quota system is currently being discussed with local communities, but subsistence use would be issued tags from the community total. Numbers of defence killings (during 1978 to 1982) within the N.W.T. range of the barren ground grizzly ranged from 0 to 12, with an average of 5 per year.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

Link 7 of MEMP Hypothesis No. 3 discusses the potential impact of problem bear removal on the abundance of grizzly bears. Given that the maximum sustainable yield for the Mackenzie Delta grizzly bear population was estimated to be 7-8 animals, it is not unreasonable to expect that the combined commercial quota and subsistence harvest could exceed or equal the maximum sustainable yield in some years. As defence killing of grizzly bears would add to the total mortality, the combined effects of all man-caused mortality could result in a gradual decline in the regional bear population.

REFERENCE

Bromley, M. 1988. The status of barren ground grizzly bear in Canada. Department of Renewable Resources, N.W.T. 65 p.

Inuvialuit Wildlife Studies - Grizzly Bear Research

BREAM PROJECT OVERVIEW NO. M3-3

PRINCIPAL INVESTIGATORS:	P. Clarkson and I. Liepins
AFFILIATION:	Department of Renewable Resources, N.W.T.
FUNDING SOURCE:	Department of Renewable Resources, N.W.T.
EXPECTED COMPLETION DATE:	1992
RELEVANT HYPOTHESIS NO.:	MEMP 3

BRIEF PROJECT DESCRIPTION

A five-year study of grizzly bears in the area between Liverpool Bay and Franklin Bay, inland to the vicinity of Lac Rendez-vous was initiated in 1987. During 1987 and 1988, a total of 85 grizzly bears have been captured and radio-collared.

The goal of the grizzly bear research program is to develop a management information base for grizzly bear that includes population densities, distribution, productivity and habitat requirements. The capture of bears provides information on population age structure, sex ratios, physical characteristics and productivity, whereas radio-tracking of collared animals yields data on bear distributions, movements and habitat use. Additional information on sex, age, physical characteristics and kill sites is being obtained through analysis of hunter-killed bears.

Preliminary findings of the study that are relevant to MEMP relate primarily to the distribution of bears in relation to the Beaufort Sea coastline, and the use of dens by collared bears. Bears were active from May to October. Bears on the Anderson and Horton rivers tended to use their respective drainages and adjacent plateaus. Several bears in the Horton River drainage also used habitat in the Smoking Hills and on sea ice in Franklin Bay. The use of sea ice by grizzly bears will be examined more closely during the remainder of the study.

The locations of 14 dens have been determined during the study. Based on preliminary data, it appears that although grizzly bears may den in the same area during successive years, they do not reuse the same den.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This ongoing study will provide current information on the barren ground grizzly bear. Preliminary data are not directly relevant to MEMP Hypothesis No. 3, with the exception that initial observations corroborate the lack of den reuse by barren ground grizzly bear. However, demographic data may be of value in future impact assessments for site-specific projects. Radio relocations may also provide an opportunity to assess the responses of grizzly bears to human activity and disturbances (Links 3 and 5), and to determine the combined effects of the commercial quota, subsistence harvest and defence killing on the regional population.

REFERENCE

Clarkson, P. and I. Liepins. 1989. Inuvialuit Wildlife Studies. Grizzly bear research. Wildlife Management Advisory Council (NWT), Technical Reports No. 3 and 8.

Safety in Bear Country - A Reference Manual

BREAM PROJECT OVERVIEW NO. M3-4

PRINCIPAL INVESTIGATOR:	M. Bromley
AFFILIATION:	Department of Renewable Resources, N.W.T.
FUNDING SOURCE:	Department of Renewable Resources, N.W.T.
COMPLETION DATE:	Complete
RELEVANT HYPOTHESIS NO.:	MEMP 3

BRIEF PROJECT DESCRIPTION

The manual summarizes information on human-bear conflicts (polar, grizzly and black bear), and recommends techniques, products and practices to reduce the chances of injury or property damage resulting from confrontations with bears. The manual is intended for use by industry, government agencies, and local residents in training staff or residents to minimize human-bear encounters.

Information is provided on the basic biology of bears (specific to the N.W.T.), bear behaviour, and methods for avoiding human-bear encounters. Methods discussed include camp design and maintenance, use of bear detection systems for camps, bear deterrent methods, and the use of firearms.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

Link 7 of MEMP Hypothesis No. 3 describes the need for the use of effective bear detection and deterrent techniques. The manual was intended for and provides a guide for training of industry and government staff, which may help to reduce that number of bear-human encounters and the need for removal of problem bears.

Use of Aversive Conditioning to Reduce Grizzly Bear/Human Conflicts in the North Slope Oilfield

BREAM PROJECT OVERVIEW NO. M3-5

PRINCIPAL INVESTIGATORS:	A. Ott and R. Schideler
AFFILIATION:	Alaska Department of Fish and Game, Habitat Division, Fairbanks, AK
FUNDING SOURCE:	Alaska Oil and Gas Association
EXPECTED COMPLETION DATE:	1994
RELEVANT HYPOTHESIS NO.:	MEMP 3

BRIEF PROJECT DESCRIPTION

A 3-year study of grizzly bear responses to oilfield activity and aversive conditioning (e.g., nonlethal projectiles such as plastic bullets) will be initiated during the summer of 1991 within the North Slope Oilfield in Alaska.

During the first field season (Phase I), six bears will be outfitted with radio collars and tracked by aircraft and ground vehicles. The first year of the study will be devoted primarily to the collection of baseline information on the use of the oilfield region by grizzly bears. Collared bears will be relocated and visually observed three times a day. The location of the bear relative to oilfield facilities and humans and their behaviour will be documented. An automated monitoring system will also be established at a major landfill site to determine the frequency, timing and duration of landfill use by grizzly bears. Information on response distances of bears to human disturbances, and interactions between bears and humans will be obtained through visual observations and interviews. A secondary task during the first year of study will be to determine den use (e.g., location, entrance and emergence times) by bears whose home range includes the oilfield area.

During the second and third years of the study (Phase II), bears will be monitored through aerial and radio-tracking surveys to determine their response to a program of nonlethal deterrents. The intent is to train bears to avoid human activity centres and humans on the ground, without altering their use of natural habitats within the oilfield. A nonlethal projectile such as a plastic slug will be used as the deterrent. The frequency of relocations and visual observations will be similar to that proposed in the Phase I study.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

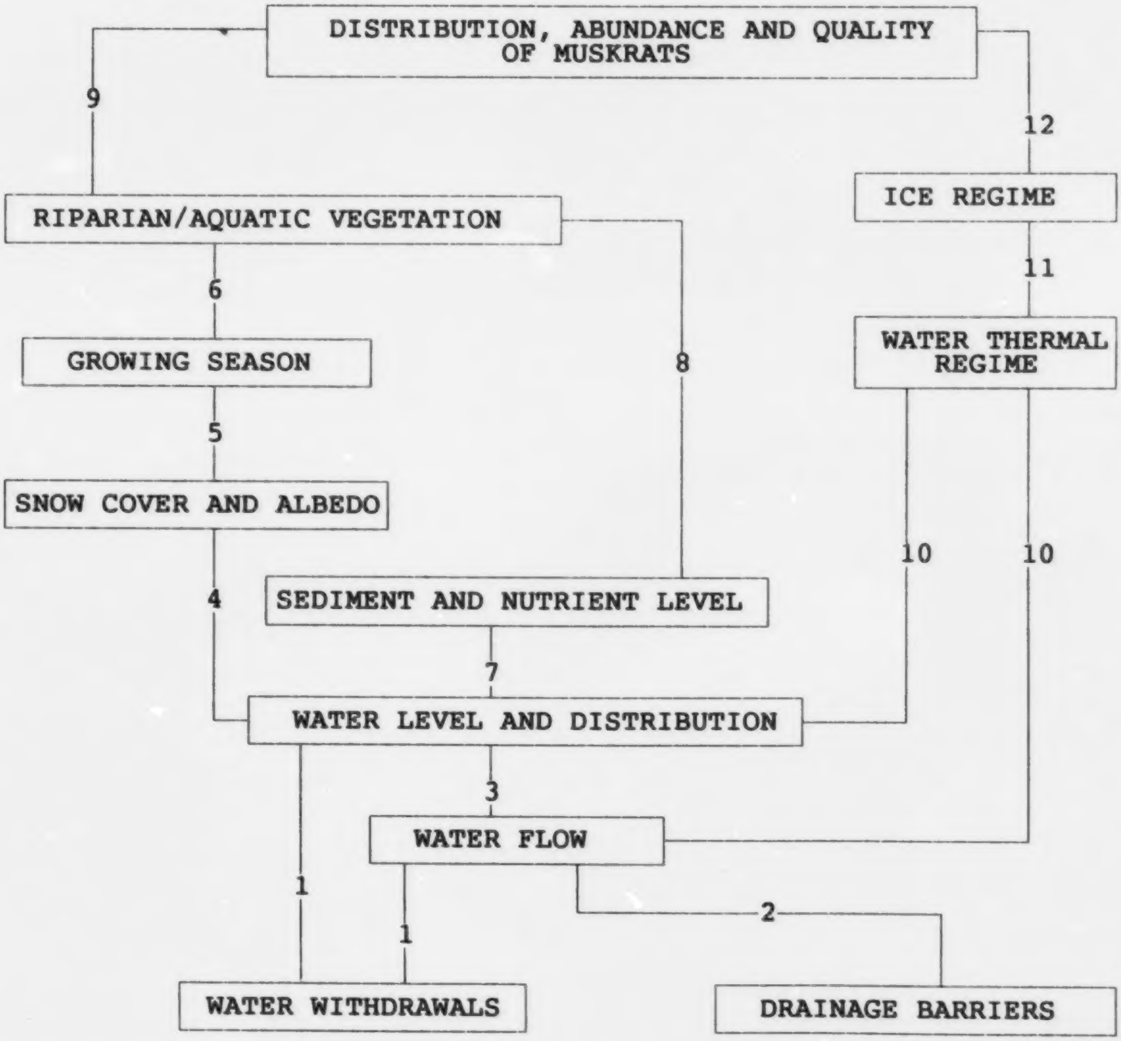
Link 7 of MEMP Hypothesis No. 3 addresses the potential for a decrease in the grizzly bear population as a result of removal of problem animals. The above study will provide detailed information on the response of grizzly bears to deterrents in terms of behavioural responses and habitat use, as well as the effectiveness of deterrents in altering bear behaviour in relation to humans and facilities. If such techniques are successful, the potential for losses of problem bears and resultant declines in bear abundance would be substantially reduced.

OTHER RELEVANT PROJECTS

PROJECT	TITLE	PAGE
MEMP 1-4	Vegetation mapping of the Yukon Coastal Plain using Landsat thematic mapper imagery	280
MEMP 2-1	Road dust and its environmental impact on Alaskan taiga and tundra	285

MEMP HYPOTHESIS NO. 4

OIL AND GAS DEVELOPMENT ACTIVITIES WILL ALTER THE WATER REGIME AND DECREASE MUSKRAT POPULATION


DISTRIBUTION, ABUNDANCE AND QUALITY OF MUSKRATS
9
12
ICE REGIME
RIPARIAN/AQUATIC VEGETATION
11
6
GROWING SEASON
8
WATER THERMAL REGIME
5
SNOW COVER AND ALBEDO
10
10
4
SEDIMENT AND NUTRIENT LEVEL
7
WATER LEVEL AND DISTRIBUTION
3
WATER FLOW
1
1
2
WATER WITHDRAWALS
DRAINAGE BARRIERS

LINKAGES

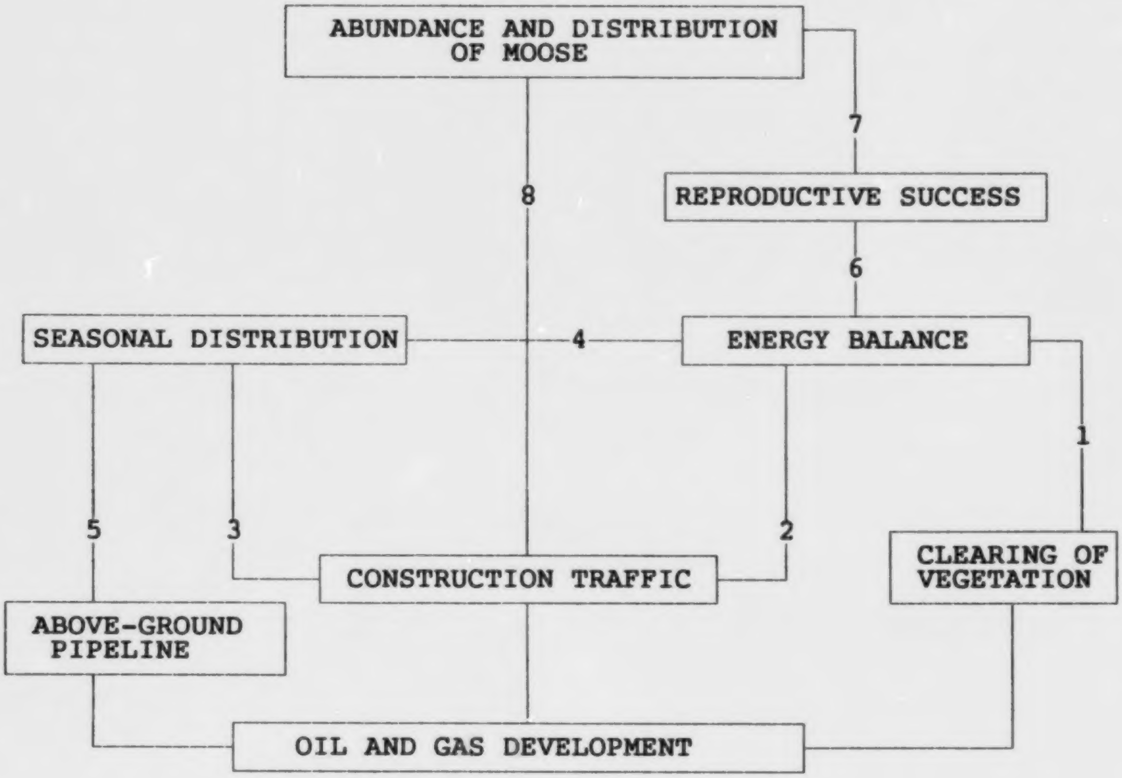
1. Water withdrawals will decrease water flow in smaller streams and water levels in smaller lakes.
2. Physical drainage barriers across the Mackenzie Delta will interrupt the pattern of water flow.
3. Patterns of water flow determine water levels and distribution.
4. The timing and extent of overbank flooding determine the duration of snow cover and the albedo.
5. The duration of snow cover and albedo influence the length of the growing season.
6. The length of the growing season influences the growth and species composition of riparian and aquatic vegetation.
7. The timing and extent of overbank flooding affect the levels and distribution of nutrients and sediments.
8. The levels and distribution of nutrients and sediments influence the growth and species composition of riparian and aquatic vegetation.
9. The growth and species composition of riparian and aquatic vegetation affect the population size and quality of muskrats through influences on feeding and survival.
10. Changes in water flow and water level affect the water thermal regime.
11. The water thermal regime affects the ice regime.
12. The ice regime affects survival of muskrats.

RELEVANT PROJECTS

PROJECT	TITLE	PAGE
MEMP 1-4	Vegetation mapping of the Yukon Coastal Plain using Landsat thematic mapper imagery	280

MEMP HYPOTHESIS NO. 5

OIL AND GAS DEVELOPMENT CONSTRUCTION AND CLEARING ACTIVITIES AND THE PRESENCE OF AN ABOVE-GROUND PIPELINE WILL CHANGE THE ABUNDANCE AND DISTRIBUTION OF MOOSE



LINKAGES

1. Wood-chipping operations, seismic lines, right-of-way, and other clearing will increase the amount of food available to moose in the short to medium term.

2. Construction activities and associated traffic will disturb and harass female moose and their young and cause individuals to expend more energy to locate suitable habitat.

3. Construction activities and associated traffic will disturb moose populations and lead to a change in distribution and the location of some individuals in alternative habitats and areas.

4. Changes in the seasonal distribution of moose will increase the amount of energy required for some individuals to locate suitable habitat.

5. An above-ground pipeline will prevent the passage of moose, which will lead to changes in migration patterns.

6. The energy balance of an adult determines its reproductive success.

7. Reproductive success determines, in part, the number of moose in the population.

8. Increased traffic associated with development will result in increased numbers of moose killed through collisions with vehicles.

Long-term Success of Seeded Species and their Influence on Native Species Invasion at Abandoned Rig Site A-01, Caribou Hills, N.W.T.

BREAM PROJECT OVERVIEW NO. M5-1

PRINCIPAL INVESTIGATOR:	W. Younkin
AFFILIATION:	Hardy BBT Limited
FUNDING SOURCE:	Canadian Arctic Gas Study Group, Esso Resources Canada and DIAND
EXPECTED COMPLETION DATE:	Ongoing
RELEVANT HYPOTHESIS NO.:	MEMP 5, 6 and 16

BRIEF PROJECT DESCRIPTION

Seeding tests were established in June, 1973 on an abandoned rig site in the Caribou Hills, 40 km north of Inuvik, N.W.T., to determine the cover success of selected grasses when seeded separately and in a mixture and the influence of various seed applications on natural succession. The undisturbed vegetation in the region is low shrub-heath dominated by dwarf birch and willow, with an understorey of heaths and herbs.

The study, conducted over a 12-year period, confirmed that although Nugget Kentucky bluegrass and Arctared creeping red fescue are slower-establishing species, they are winter hardy and can provide a maintenance-free, long-lasting cover in this region. However, an extremely dense root mat and litter layer produced by both species curtailed invasion by native species to less than 15 percent cover after the 12 years.

The seed mix containing the above species as well as Engmo timothy, Frontier reed canary-grass, and Prolific spring rye provided high first-year cover (40%), which died back considerably following the first winter. By the third growing season, however, the cover produced by the long-lived species plus the litter provided a total cover (75%) approaching that achieved individually by Nugget Kentucky bluegrass and Arctared creeping red fescue (80%). Invasion of native species into these plots was significantly higher than in the other seeded plots, reaching 25% cover by year 3 and equalling that (80%) in unseeded control plots by year 12.

Adequate cover for erosion control for many situations was produced by the seed mix in the first year and individually by Nugget Kentucky bluegrass and Arctared creeping red fescue after the second year.

Although the rate of native species invasion is more rapid in the seed mix and control plots, it still only represents an increase of a relatively few common pioneer species and, as a plant community, is still a long way from the form and complexity of the undisturbed community. A prudent estimate of the time required to re-establish the natural community in this region might be in the order of 60 to 80 years. If this is true, the real difference in the rate of natural recovery among the various seeding treatments are relatively small and may have little effect on the time needed to achieve the species composition and structure of the undisturbed community.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study is relevant to the hypotheses that are concerned with the re-establishment of plant cover for the purpose of providing wildlife habitat (MEMP Hypothesis No. 5 and 6) and reducing sedimentation (MEMP Hypothesis No. 16).

The study demonstrates that a self-sustaining plant cover adequate to control surface erosion can be initiated immediately following disturbance of tundra and, thereby, protect adjacent water resources and provide hospitable conditions for the eventual re-establishment of the native plant community.

Revegetation Monitoring of the Interprovincial Pipe Line (NW) Ltd. Norman Wells to Zama Pipeline

BREAM PROJECT OVERVIEW NO. M5-2

PRINCIPAL INVESTIGATOR:	H. Martens
AFFILIATION:	Hardy BBT Limited, Calgary, Alberta
FUNDING SOURCE:	Interprovincial Pipe Line (NW) Ltd. and INAC
EXPECTED COMPLETION DATE:	Ongoing
RELEVANT HYPOTHESIS NO.:	MEMP 5, 6 and 16

BRIEF PROJECT DESCRIPTION

The Norman Wells pipeline is the first completely buried oil pipeline in the discontinuous permafrost zone in northern Canada. The 869 km long pipeline from Norman Wells, N.W.T. to Zama, Alberta is located in thaw-sensitive terrain in a relatively remote part of this region. Main pipeline construction was completed during the winters of 1983-84 and 1984-85. Seeding of the pipeline right-of-way and the associated roads and facilities was completed during the winter immediately following construction. Remedial seeding programs have been carried out each year following construction, as required. The objectives of the revegetation monitoring program, conducted annually from 1984 to 1987, were to:

1. assess the revegetation success along the right-of-way and on associated construction sites and identify areas that require additional seed and/or fertilization;
2. monitor permanent transects to assess vegetation recovery over time for various land types, construction sites and revegetation treatment; and
3. monitor revegetation trial sites established as part of a cooperative monitoring program with Indian and Northern Affairs Canada (INAC) to determine the effect of seed and fertilizer on revegetation success and natural recovery.

Key findings of the last monitoring program conducted during the fall of 1987 are listed below.

1. Four years following initial seeding and fertilization, surface soils were stable and erosion was minimal along the Norman Wells Pipeline.
2. Mineral Soils
    a. The application of seed (30 kg/ha on overland, 50 kg/ha on slopes) and fertilizer (250 kg/ha) provided an average 18 percent first year cover, 36 percent second year cover, 50 percent third year cover, and 66 percent fourth year cover, without maintenance fertilization.
    b. A first-year cover of 18 percent proved to be adequate for controlling erosion in most situations.
    c. Under favourable site conditions, first-year vegetation cover was doubled by doubling the rate of fertilizer application (from 250 to 500 kg/ha).

   d. Boreal creeping red fescue, Revenue slender wheatgrass, creeping foxtail and Vantage reed canary grass were the most successful of the seeded species after four years. Climax timothy, common in the first two years, had almost died out after four years.

3. Peat Soils

   a. The routine application of seed and fertilizer on graded peat bogs produced only marginal increases in native or seeded plant cover after four years.

   b. The routine application of seed and fertilizer on shallow peat veneers generally produced plant cover similar to that on mineral soils.

4. Encroachment on Native Species

   a. The encroachment of native species is most favourably influenced by the addition of fertilizer. The application of seed alone or in combination with fertilizer decreased the rate of native encroachment.

   b. Shrub and tree cover on the right-of-way was greatest where native species (e.g., willow, trembling aspen, balsam poplar) were common in the adjacent plant communities, providing up to 11 percent ground cover in unseeded areas three years after construction.

5. Regeneration of Wood Harvest Sites

   a. Three and four years after clear cutting of wood harvest areas at selected points along the pipeline, native vascular plant cover averaged 40 percent. Common species included *Rosa spp., Cornus stolonifera, Alnus crispa*, and *Calomagrostis canadensis.* Scattered shrubs and trees varying in height from 1.0 to 2.5 m included *Betula papyrifero, Populus balsamifera, Populus tremuloides* and *Alnus crispa.*

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study provides information on the success of revegetation of area disturbed by pipeline construction and the invasion of native herbaceous and woody species. This is directly relevant to MEMP Hypotheses Nos. 5 and 6 as it relates to plant cover, and Hypothesis

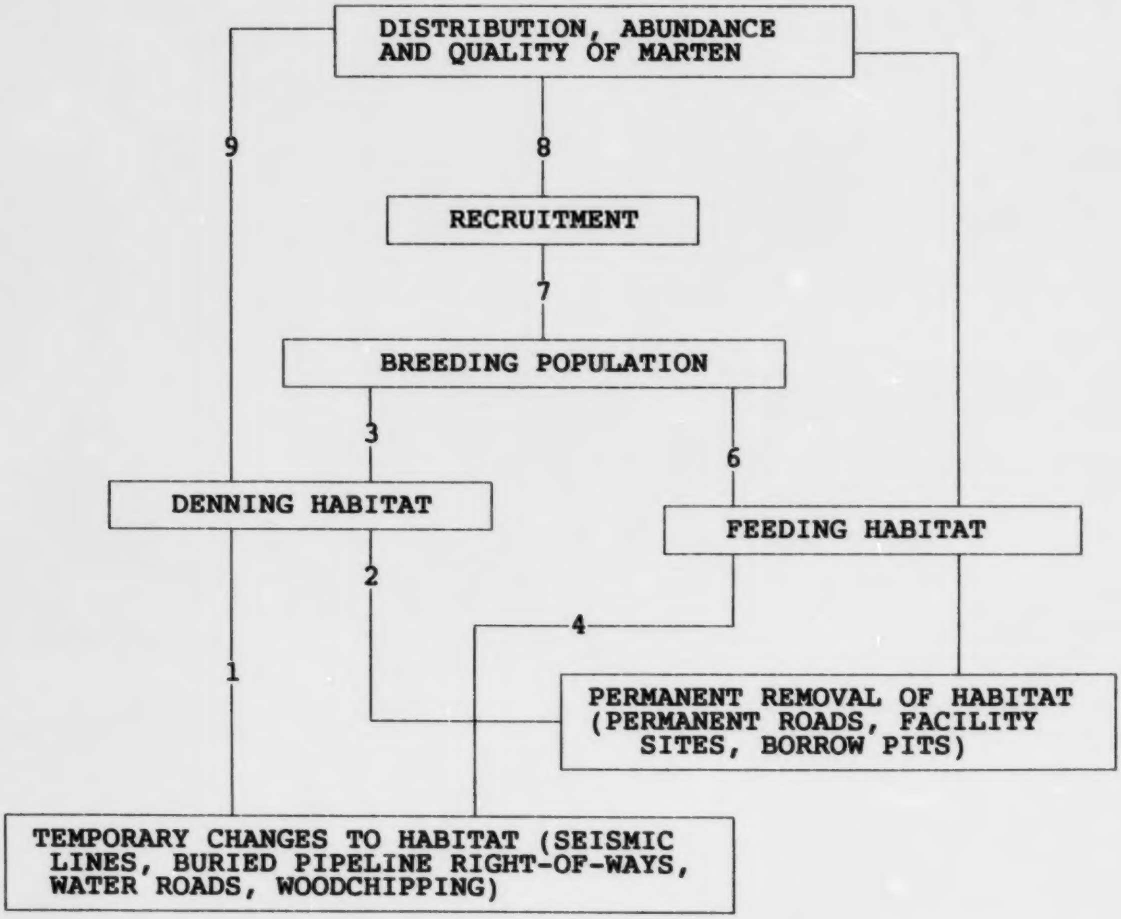
No. 16 as it relates to surface erosion and reduction of water quality. Results have shown that the seeded plant cover produced in the first year following construction is adequate to control soil erosion in most situations. Continued monitoring of the permanently established transects will provide information on the rate of native plant recovery on the right-of-way, wood harvest areas and other associated facilities.

OTHER RELEVANT PROJECTS

PROJECT	TITLE	PAGE
MEMP 1-1	Successful plant colonizers on disturbances in tundra areas of northwestern Canada	276
MEMP 1-4	Vegetation mapping of the Yukon Coastal Plain using Landsat thematic mapper imagery	280

MEMP HYPOTHESIS NO. 6

OIL AND GAS EXPLORATION AND DEVELOPMENT ACTIVITIES THAT ALTER HABITAT PERMANENTLY OR TEMPORARILY WILL INFLUENCE THE DISTRIBUTION AND ABUNDANCE OF MARTEN


DISTRIBUTION, ABUNDANCE AND QUALITY OF MARTEN
9
8
RECRUITMENT
7
BREEDING POPULATION
3
6
DENNING HABITAT
FEEDING HABITAT
2
4
1
PERMANENT REMOVAL OF HABITAT (PERMANENT ROADS, FACILITY SITES, BORROW PITS)
TEMPORARY CHANGES TO HABITAT (SEISMIC LINES, BURIED PIPELINE RIGHT-OF-WAYS, WATER ROADS, WOODCHIPPING)

LINKAGES

1. Seismic lines, wood-chip operations, temporary winter roads and pipeline rights-of-way will temporarily decrease marten denning habitat.

2. Permanent roads, facility sites and borrow pits will permanently decrease marten denning habitat.

3. A decrease in denning habitat will decrease the local breeding population of marten.

4. Seismic lines, wood-chip operations, temporary winter roads and pipeline rights-of-way will temporarily increase marten feeding habitat.

5. Permanent roads, facility sites and borrow pits will permanently decrease marten feeding habitat.

6. An increase in feeding habitat will increase the local breeding population of marten through increased survival.

7. The size of the breeding population of marten influences recruitment.

8. Recruitment contributes to marten population levels.

9. A decrease in denning habitat will increase the emigration of marten to surrounding areas.

10. An increase in feeding habitat will increase the immigration of marten from surrounding areas.

Sahtu District Marten Research

BREAM PROJECT OVERVIEW NO. M6-1

PRINCIPAL INVESTIGATORS:	P. Latour and K. Poole
AFFILIATION:	Department of Renewable Resources, N.W.T.
FUNDING SOURCE:	Department of Renewable Resources, N.W.T.
EXPECTED COMPLETION DATE:	1992
RELEVANT HYPOTHESIS NO.:	MEMP 6

BRIEF PROJECT DESCRIPTION

A 3-year study of marten in a 36 km^2 area west of Norman Wells was initiated by the N.W.T. Game Branch during fall 1989. Half of the study area is comprised of mature black spruce forest, while the remaining area is comprised of a 15-year old burn. The objectives of the research program are to:

1. determine summer and winter home range sizes;

2. document the pattern and timing of dispersal of animals into and out of the study area:

3. assess the abundance of major foods (e.g., small mammals and berries); and

4. evaluate the distribution and abundance of habitat in terms of vegetation cover, deadfall, overhead cover and snow depth.

Home range sizes and movements will be determined by radio tracking collared marten in the study area, as well as through track count surveys. Radio relocations will be done at 7-10 day intervals from the ground and aircraft. More intensive relocations of some animals will be used to assess behaviour patterns and habitat use.

Note: As of 1990, only one report for this study has been published. The report describes marten harvest trends based on carcasses collected from Fort Good Hope, Fort Franklin and Fort Rae (K.G. Poole. 1990. Marten Research in the N.W.T., 1989-90. Department of Renewable Resources, Yellowknife, N.W.T.).

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

MEMP Hypothesis No. 6 concludes that "only changes in habitat that result in loss of a substantial part of the home range of a marten are expected to decrease marten numbers". Because most industrial activities were predicted to result in the loss of only small portions of the home range of individual marten, habitat changes were concluded to be insignificant. However, as discussed in the MEMP report, no information is available on the home range sizes of marten in the Northwest Territories. As a major focus of the marten research program is to determine the home range sizes of marten, information from this research program will be useful in defining what types and sizes of habitat disturbance will significantly affect the home ranges of marten.

In addition, the research program will assess the relative abundance of important food species for marten, and the effects of changes in the availability of food items on marten diet and abundance. Such information will be directly relevant in substantiating Links 4, 5, 6 and 9 (i.e., effects of seismic lines and permanent roads on feeding habitat for marten, and the resultant effects on marten productivity and emigration). Radio-tracking of breeding female marten, as well as young-of-the-year will provide information of importance to Links 7 and 8 (effects of the size of the marten population on recruitment, and changes in population levels). The combined results of the food analysis and the radio-tracking study may also be relevant to Link 10 (i.e., increases in feeding habitat will increase immigration from adjacent areas).

Food Habits of Marten, *Martes americana*, in the South-Central Yukon Territory

MEMP PROJECT OVERVIEW NO. M6-2

PRINCIPAL INVESTIGATORS:	B.G. Slough, W.R. Archibald, S.S. Beare and R.H. Jessup
AFFILIATION:	Fish and Wildlife Branch, Department of Renewable Resources, Yukon
FUNDING SOURCE:	Fish and Wildlife Branch, Department of Renewable Resources, Yukon
COMPLETION DATE:	Complete
RELEVANT HYPOTHESIS NO.:	MEMP 6

BRIEF PROJECT DESCRIPTION

The diet of marten in a 14 km^2 area in the upper Yukon River basin was undertaken by the Yukon Fish and Game Branch during 1979 to 1981. Marten were live-trapped at three-week intervals between May and September. Scats were collected from the trapping grid during each live-trapping session, as well as during winter radio-tracking studies. The major food of marten during most months was microtine rodents, primarily red-backed voles (*Clethrionomys rutilus)*. Other seasonally abundant food items included overwintering and fresh fruits (e.g., Crowberry [*Empetrum nigrum*]), birds (including eggs and upland game birds), and snowshoe hares (*Lepus americanus*). Use of snowshoe hares coincided with the winter of the peak year of snowshoe hare abundance, when starving and cold-stressed animals were common.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

Links 4 and 5 of MEMP Hypothesis No. 6 address the potential for specific project activities to increase or decrease the availability of food for marten. The above study, although outside the BREAM study area, provides detailed information on marten diets that may be useful in predicting effects of specific project activities on the availability and abundance of important food species.

REFERENCE

Slough, B.G., W.R. Archibald, S.S. Beare and R.H. Jessup. 1989. Food habits of marten, martes americana, in the south-central Yukon Territory. Canadian Field Naturalist 103: 18-22.

Movements and Habitat Use by Transplanted Marten in the Yukon Territory

MEMP PROJECT OVERVIEW NO. M6-3

PRINCIPAL INVESTIGATOR: B.G. Slough
AFFILIATION: Fish and Wildlife Branch, Yukon Department of Renewable Resources, Whitehorse, Yukon
FUNDING SOURCE: Fish and Wildlife Branch, Yukon Department of Renewable Resources, Whitehorse, Yukon
COMPLETION DATE: Complete
RELEVANT HYPOTHESIS NO.: MEMP 6

BRIEF PROJECT DESCRIPTION

As part of a program to transplant 171 marten to the southwest Yukon Territory in February 1984 and January 1987, 36 marten were fitted with radio collars to determine survival, movements and habitat use of the transplanted animals. Of relevance to MEMP Hypothesis No. 6, estimates of home range size were determined for transplanted animals that became residents in the study area (i.e., maintenance of the same home range for more than 3 months). Home range estimates were 6.0 km^2 for a resident male, and an average of 1.9 km^2 for three resident females.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

As discussed for Project Overview M6-1, estimates of home range sizes are required to determine the importance of habitat and den loss as a result of facility development and site clearing. Although sample sizes in this study are small, and home ranges of transplanted animals may not accurately reflect home ranges of undisturbed animals, the study does provide several estimates of home range size that could be utilized in evaluating this hypothesis.

REFERENCE

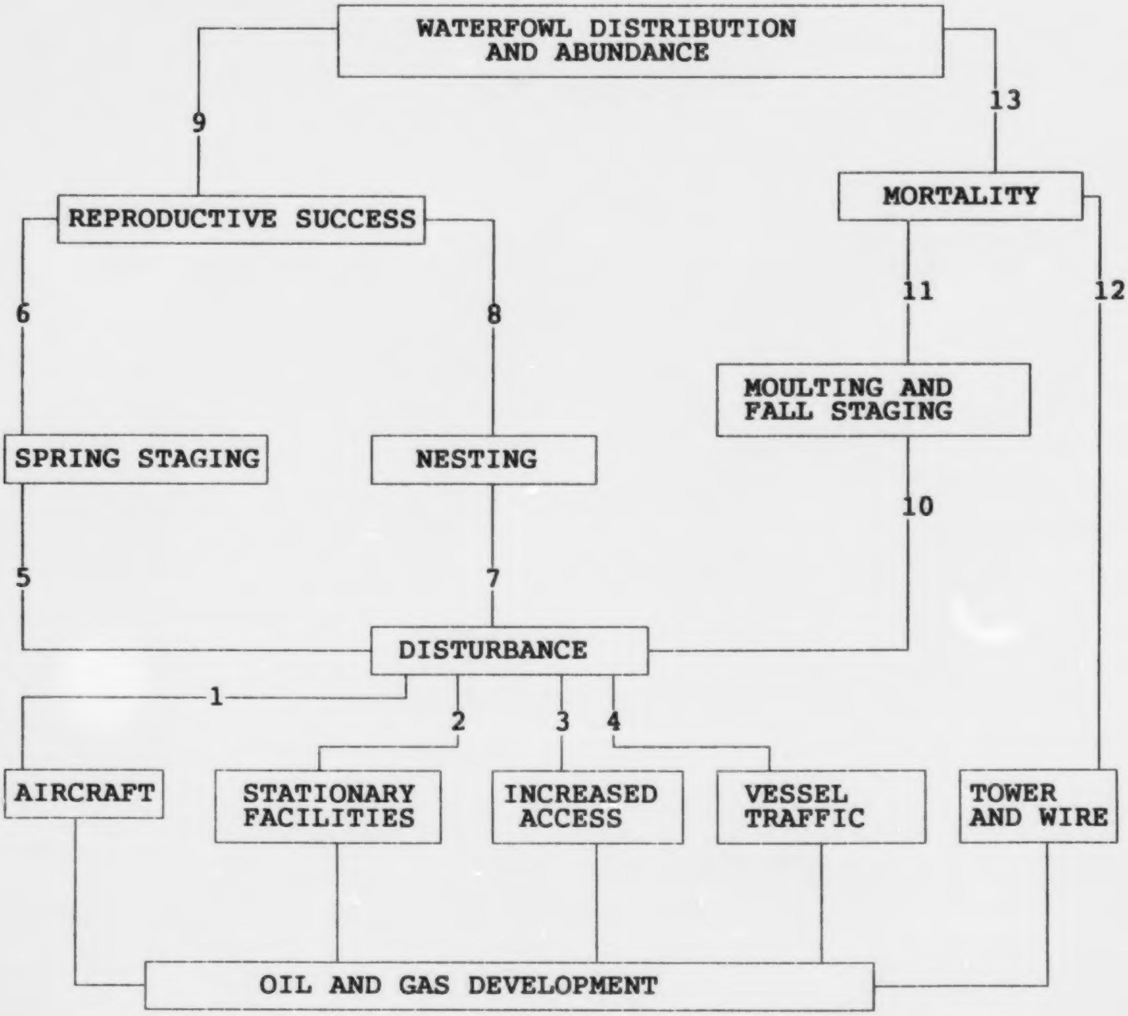
Slough, B.G. 1989. Movements and habitat use by transplanted marten in the Yukon Territory. Journal of Wildlife Management 53: 991-997.

OTHER RELEVANT PROJECTS

PROJECT	TITLE	PAGE
MEMP 1-1	Successful plant colonizers on disturbances in tundra areas of northwestern Canada	276
MEMP 1-4	Vegetation mapping of the Yukon Coastal Plain using Landsat thematic mapper imagery	280
MEMP 5-1	Long-term success of seeded species and their influence on native species invasion at abandoned Rig Site A-01, Caribou Hills, N.W.T	310
MEMP 5-2	Revegetation monitoring of the Interprovincial Pipe Line (NW) Ltd. Norman Wells to Zama pipeline	311

MEMP HYPOTHESIS NO. 7

DISTRIBUTION ASSOCIATED WITH HYDROCARBON DEVELOPMENT IN OR NEAR WATERFOWL STAGING, MOULTING OR NESTING AREAS WILL AFFECT THE ABUNDANCE AND DISTRIBUTION OF WATERFOWL



LINKAGES

1. Increases in aircraft overflights will increase disturbance to waterfowl.

2. the presence of exploratory, processing and distribution facilities will increase disturbance to waterfowl.

3. Increased access will increase disturbance to waterfowl.

4. Increased vessel traffic on the Mackenzie River will increase disturbance to waterfowl.

5. Increased disturbance will displace waterfowl in spring staging areas, and interfere with feeding, courtship and nesting.

6. Increased energy costs due to displacement during spring staging will decrease reproductive success.

7. An increase in disturbance will cause an increase in nest desertion and brood loss.

8. Increased nest desertion and brood loss will decrease reproductive success.

9. A decrease in reproductive success will reduce the abundance and alter the distribution of waterfowl.

10. Increased levels of disturbance will increase energy costs during moulting and fall migration.

11. Increased energy costs during moulting and fall migration will cause an increase in mortality.

12. The presence of towers and wires will increase mortality of waterfowl.

13. Increased mortality will reduce local abundance and alter the distribution of waterfowl.

Use of Gravel Causeways by Nesting Common Eiders, Beaufort Sea, Alaska, 1990

BREAM PROJECT OVERVIEW NO. M7-1

PRINCIPAL INVESTIGATOR:	D. Wiggins
AFFILIATION:	LGL Alaska Research Associates Inc.
FUNDING SOURCE:	BP Exploration (Alaska) Inc.
COMPLETION DATE:	Complete
RELEVANT HYPOTHESIS NO.:	MEMP 7

BRIEF PROJECT DESCRIPTION

As part of an ongoing study, nest-site selection and breeding success of Common Eiders was monitored on the Endicott and West causeways, and Duck Island 1 and 2 in 1990. On Endicott Causeway, eiders first nested in 1988 (2 nests), and nests have increased since that time (4 in 1989; 20 in 1990). In 1990, 4 females nested on West causeway and 15 nested on Duck Island 1 and 2. Hatching success was within normal ranges. A large proportion of the nests were found near the base of the Endicott causeway on the west side, although there apparently was no more driftwood accumulation in this area than at other transects studied. However, driftwood accumulations were higher above the waterline near the base of the causeway than further out, thereby reducing the likelihood of the nest being flooded during summer storms. In addition, this area is closer to the mainland ponds where the eiders travel with their broods after hatching, and the micro-climate on the west side of the causeway is likely warmer and less windy than elsewhere.

Further studies include the feasibility of transplanting dune grass to the study areas, which is expected to increase the numbers of nesting eiders on the Endicott causeway.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

MEMP Hypothesis No. 7 describes a possible mechanism for environmental effects caused by hydrocarbon developments in or near waterfowl staging, moulting or nesting areas. In this hypothesis, the VEC is waterfowl that stage, moult or nest in the study area and may be affected by development activities in this area. Link 2 indicates that the presence of exploratory, processing and distribution facilities may increase disturbance to waterfowl. The study described above indicates that permanent facilities such as causeways may, in time and with some habitat modification, increase rather than decrease the abundance and distribution of eiders (Links 7, 8 and 9).

REFERENCE

Wiggins, D.A. and S.R. Johnson. In prep. Use of gravel causeways by nesting common eiders, Beaufort Sea, Alaska, 1990. Draft. Rep. by LGL Alaska Res. Assoc. Inc. for BP Exploration (Alaska) Inc, Anchorage.

The Status of Snow Geese in the Sagavanirktok River Delta area, Alaska. A Progress Report: 1980-1990

BREAM PROJECT OVERVIEW NO. M7-2

PRINCIPAL INVESTIGATOR:	S.R. Johnson
AFFILIATION:	LGL Alaska Research Associates Inc.
FUNDING SOURCE:	BP Exploration (Alaska) Inc.
EXPECTED COMPLETION DATE:	1991
RELEVANT HYPOTHESIS NO.:	MEMP 7

BRIEF PROJECT DESCRIPTION

The primary objectives of this study were to: (1) determine the general distribution and number of Snow Geese in the Sagavanirktok River delta area during the brood-rearing period; (2) determine the ages, sexes and condition of the geese; and (3) band all Snow Geese and record the identity of birds that returned to the colony. Industrial development proceeded during the winter of 1984-85, which involved construction of a road from Prudhoe Bay that bisected the Delta and extended as a causeway several kilometres offshore, passing seaward about 1 km east of Duck Island. Following completion of the access road and causeway in 1985, several modifications (i.e., dock construction, drilling operations, pipeline construction) were carried out and continued to 1987. During the 1988 breeding season, drilling and production took place on the artificial islands. However, activities within the Delta area used by Snow Geese were limited to travel along the access road and causeway, as well as scientific biophysical investigations. Due to the intensive banding operations carried out over the 11-year program, considerable individual-specific information has been obtained on migration routes, winter distribution and mortality.

Prior to construction of the road and causeway, there was concern that this development would act as a barrier to the movements of Snow Geese as they dispersed from Howe Island after hatching in early July, particularly those groups moving eastward from Howe Island where the structure was to be situated. However, no significant differences were noted between numbers of geese captured east (vs. west) of the structure before and after construction, although the distance of dispersal increased after 1985 (the year following road/causeway construction). This may have been due to either increased activity in the area or to a three-fold increase in population numbers from 1980 (165 geese) to 1985 (600 geese).

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

MEMP Hypothesis No. 7 describes a possible mechanism for environmental effects caused by hydrocarbon developments in or near waterfowl staging, moulting or nesting areas. In this hypothesis, the VEC is waterfowl that stage, moult or nest in the study area and may be affected by development activities in this area. Link 2 indicates that the presence of exploratory, processing and distribution facilities may increase disturbance to waterfowl. The study described above indicates that permanent facilities such as roads and causeways, as well as other increases in human activity related to drilling apparently do not adversely affect brood rearing, dispersal or abundance of Snow Geese.

REFERENCE

Johnson, S.R. In prep. The status of snow geese in the Sagavanirktok River Delta area, Alaska. A progress report: 1980-1990. Draft. Rep. by LGL Alaska Res. Assoc. Inc. for BP Exploration (Alaska) Inc, Anchorage.

A Survey of Trumpeter Swans and their Habitat in Southern Mackenzie District, Northwest Territories: 1986

BREAM PROJECT OVERVIEW NO. M7-3

PRINCIPAL INVESTIGATOR:	K.J. McCormick
AFFILIATION:	Canadian Wildlife Service, Western and Northern Region, NWT
FUNDING SOURCE:	NOGAP
COMPLETION DATE:	Complete
RELEVANT HYPOTHESIS NO.:	MEMP 7

BRIEF PROJECT DESCRIPTION

From 27 July to 2 August, 1986, trumpeter swans were surveyed and captured in the southern Mackenzie District, NWT. The purpose of the study was to determine the distribution and abundance of swans in this region. Key morphological characteristics were measured on twenty adult swans to confirm their identification. Captured swans were also banded and collared to determine migration routes and wintering areas. The majority of the swans (83 adults and 55 cygnets in 14 broods) were concentrated in the Nahanni Butte area and in the vicinity of Camsell Bend.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL AND ASSESSMENT PROJECT

This study is considered relevant to MEMP Hypothesis No. 7, which describes a possible mechanism for environmental effects caused by hydrocarbon developments in or near waterfowl staging, moulting or nesting areas. In this hypothesis, the VEC is waterfowl that stage, moult or nest in the study area and may be affected by development activities in this area. Link 2 indicates that the presence of exploratory, processing and distribution facilities may increase disturbance to waterfowl. The study described above provides information on the abundance and distribution of trumpeter swans in the Mackenzie Delta area. These birds are highly susceptible to disturbance by human activity, which can lead to lower nesting rates and lower cygnet survivability. Trumpeter swan breeding sites in Mackenzie District are considered to be priority sites. Trumpeter swans are a rare species in Canada, and their breeding sites are potential 'Key Terrestrial Habitat Sites' (areas identified by CWS as being essential habitats of various migratory bird species).

REFERENCE

McCormick, K.J. and L.J. Shandruck. 1987. A survey of trumpeter swans and their habitat in southern Mackenzie District, Northwest Territories: 1986. CWS Tech. Rep. Ser. No. 26: 43 p.

A Review of Bird Sanctuaries in the Northwest Territories (in Response to the DIAND Northern Mineral Policy)

BREAM PROJECT OVERVIEW NO. M7-4

PRINCIPAL INVESTIGATOR:	Unknown
AFFILIATION:	Canadian Wildlife Service, Western and Northern Region, NWT
FUNDING SOURCE:	Unknown
COMPLETION DATE:	Complete
RELEVANT HYPOTHESIS NO.:	MEMP 7

BRIEF PROJECT DESCRIPTION

This report describes actions taken after the release of the Northern Mineral Policy by the Department of Indian Affairs and Northern Development in 1986. One objective of the Policy is to provide the mining industry with an atmosphere of stability and certainty regarding federal government initiatives that could have an impact on the operating environment of the industry. Access to land for exploration and development is a primary concern of the mining industry. The Policy commits the federal government to a review of Bird Sanctuary boundaries to ensure that the lands they contain are necessary to achieve the conservation objectives for which they were established. The review was undertaken by the Canadian Wildlife Service in cooperation with DIAND and GNWT Department of Renewable Resources. The review considers the sanctuaries in the context of contemporary knowledge and also considers the Bird Sanctuary regulations and CWS's approach to sanctuary management. Discussions with certain members of the mining community yielded no tangible concerns with CWS's management approach. The review resulted in a number of proposed changes to sanctuary boundaries (one delisting under review, one possible reduction in size, 5 expansions and 5 unchanged).

Individual reviews contain information on location, size, rationale for designation as a sanctuary, description (location relative to prominent topography or man-made features, dominant vegetation types, etc.), biological values (bird species summaries, seasonal occupations and activities and information on other wildlife and plant communities), boundaries, references and a map (colony locations extent of a key habitat, boundaries and areas of concentrated nesting). Of the 13 bird sanctuaries discussed in this report, 4 are within the BREAM study area. According to the regulations, virtually any land-use activity is acceptable within a sanctuary provided that there is no significant impact upon avian resources or their habitat, although the Policy does state that "mineral exploration and development activities are restricted in Bird Sanctuaries throughout the Territories". In the Beaufort area, permafrost and terrain studies, seismic surveys and exploratory hydrocarbon drilling have been conducted within Banks Island Bird Sanctuary No. 1).

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

MEMP Hypothesis No. 7 describes a possible mechanism for environmental effects caused by hydrocarbon developments in or near waterfowl staging, moulting or nesting areas. This study directly addresses the application of the Northern Mineral Policy to the current regulations of bird sanctuaries in the North.

REFERENCE

CWS. 1989. A review of bird sanctuaries in the Northwest Territories (in response to the DIAND Northern Mineral Policy). Prep. by CWS with DIAND and Dept. Renewable Resources, GNWT. 56 p. + appendices.

Tundra Swan and Brant Surveys on the Arctic coastal plain, Colville River to Staines River

BREAM PROJECT OVERVIEW NO. M7-5

PRINCIPAL INVESTIGATOR:	R.R. Ritchie
AFFILIATION:	Alaska Biological Research, Inc.
FUNDING SOURCE:	ARCO Alaska, Inc. and BP Exploration (Alaska) Inc.
COMPLETION DATE:	Complete
RELEVANT HYPOTHESES NO.:	MEMP 7 and 10

BRIEF PROJECT DESCRIPTION

Tundra swans and Brant have been traditionally important in planning oilfield development in northern Alaska. Because information about these species is limited in some areas, the authors undertook aerial waterfowl surveys in the region between Colville and Staines rivers and ground surveys between the Sagavanirktok River delta and the Kuparuk Oilfield. The study goals were to: (1) locate tundra swans in the Kuparuk Oilfield, in the Oil and Gas Lease Sale 54 (OGL 54) and in Prudhoe Bay, and to count pairs, nests, flocks and broods; and (2) determine the proximity of tundra swans, nests and broods to new or proposed drill sites. Brant studies collected information on the abundance distribution and productivity of Brant on the Coastal Plain between Colville and Staines rivers.

Increases noted in Tundra Swan numbers resulted mainly from the early and mild spring in 1990, which created highly favourable conditions for nesting. Nesting success appeared to be higher in Kuparuk Oilfield and Prudhoe Bay than in OGL 54, and the density of adults without nests was substantially lower in Prudhoe Bay than in the rest of the study area. Even with the increases in 1990, densities of both breeding and non breeding tundra swans in Kuparuk Oilfield and OGL 54 were low compared to those reported elsewhere in northern Alaska. Recorded differences between years may simply represent the normal range of variation.
Increases reported in nesting effort for Brant in 1990 were probably due to a mild spring with early snow melt, lower than normal water levels and reduced ice cover in some wetlands. Nest success and gosling survival were high and more goslings were observed during brood-rearing. These increases may also reflect normal variations in the populations.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

MEMP Hypothesis No. 7 describes the effects of disturbance associated with hydrocarbon development in or near waterfowl staging, moulting or nesting areas and MEMP Hypothesis No. 10 describes the effects of oil spills on staging and moulting waterfowl. The above project, although not within the BREAM study area, involves the examination of nesting and brooding waterfowl in and around hydrocarbon developments in a neighbouring area of the Beaufort Sea. Such studies are valuable in assessing and monitoring the effects of developments on waterfowl.

REFERENCE

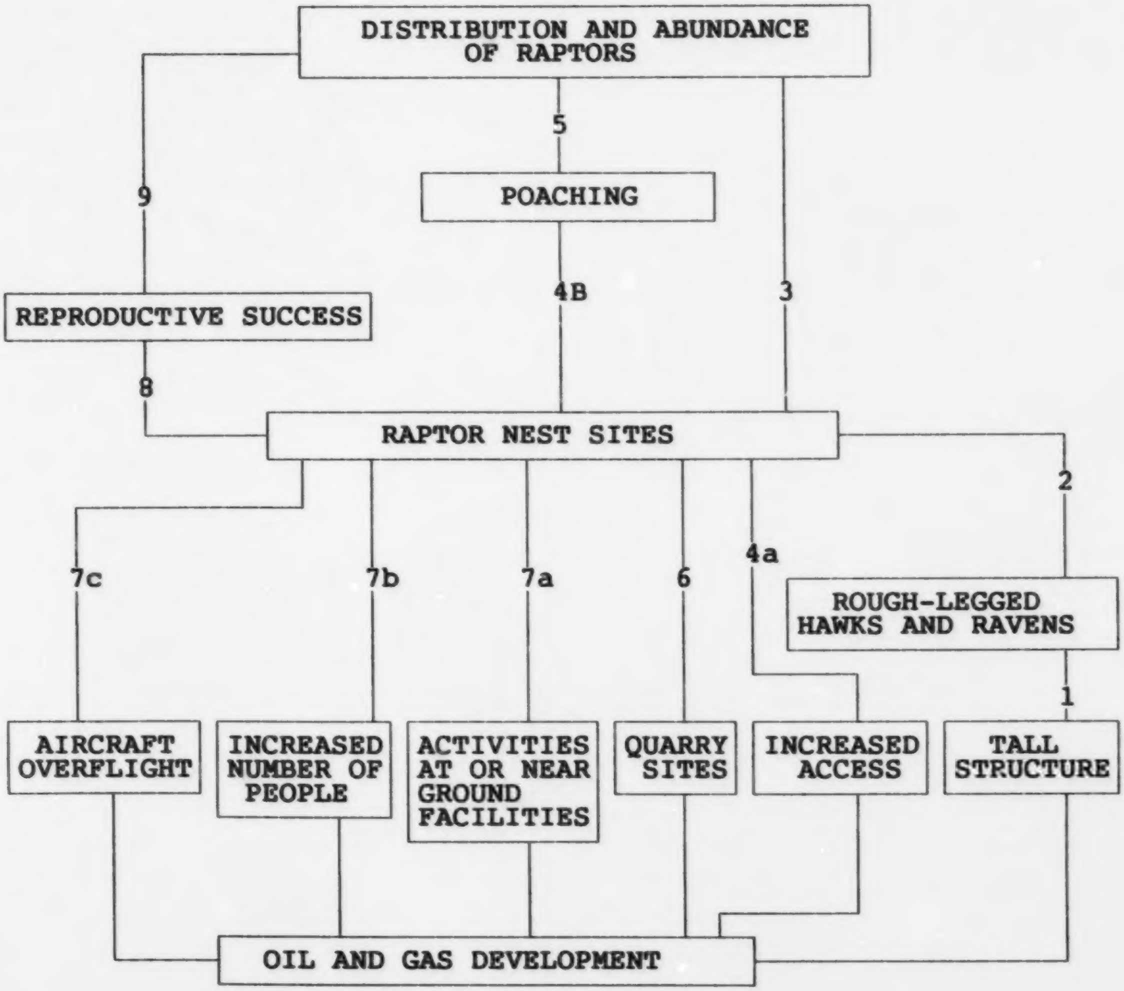
Ritchie, R.J., A.A. Stickney, P.W. Banyas and J.G. King. 1991. Tundra swan and brant surveys on the Arctic coastal plain, Colville River to Staines River. Rep. by Alaska Biological Research, Inc., Fairbanks, AK. for ARCO Alaska, Inc., Kuparuk River Unit, BP Exploration (Alaska), Inc. and The Duck Island Unit Owners, Anchorage, AK. 89 p.

OTHER RELEVANT PROJECTS

PROJECT	TITLE	PAGE
BEMP 10-3	Banks Island Bird Sanctuary No. 1 Management Plan	179
BEMP 10-4	Progress report: survey of geese and swans in the Inuvialuit Settlement Region, 1989	180
BEMP 10-5	Segregation of brant geese *Branta bernicla* wintering and staging in Puget Sound and the Strait of Georgia	181
BEMP 10-7	Spring migration of eiders, oldsquaws and glaucous gulls along offshore leads of the Canadian Beaufort Sea	185
BEMP 10-8	The avifauna of Toker Point, Tuktoyaktuk Peninsula, Northwest Territories, 1985-1987	187
BEMP 10-9	Spring migration of eiders, oldsquaws and glaucous gulls along offshore leads of the Canadian Beaufort Sea	188
BEMP 10-10	Progress report on surveys of geese and swans in the Inuvialuit Settlement Region, 1988	189
BEMP 10-11	International snow goose neckbanding project - progress report	191
BEMP 10-12	Neckbanding of Arctic geese	192
BEMP 10-13	The birds of the Beaufort Sea	193
BEMP 12-1	Response of brant and other geese to aircraft disturbance at Izembek Lagoon, Alaska	201
BEMP 12-2	Effects of aircraft on the behavior and ecology of molting brant near Teshekpuk Lake, Alaska	201
MEMP 1-4	Vegetation mapping of the Yukon Coastal Plain using Landsat thematic mapper imagery	280
MEMP 2-1	Road dust and its environmental impact on Alaskan taiga and tundra	285

MEMP HYPOTHESIS NO. 8

DISTURBANCE AND HABITAT ALTERATIONS DUE TO HYDROCARBON DEVELOPMENT WILL ALTER THE DISTRIBUTION AND/OR ABUNDANCE OF RAPTOR SPECIES



LINKAGES

1. Ravens and rough-legged hawks will establish nest sites in tall structures.

2. Gyrfalcons will take over some of the nests of ravens and/or rough-legged hawks that are in the tall structures.

3. The presence of gyrfalcon nests in tall structures will result in an increase in the abundance and/or range of this species.

4a. Roads, pipeline rights-of-way and seismic lines will allow access to raptor nest sites.

4b. Increased access by people will result in increased poaching of eggs and young.

5. Increased poaching will result in a reduction of peregrine falcon and gyrfalcon populations.

6. Borrow sites can either create or destroy raptor nesting habitat.

7a. Persistent aircraft activity at low altitudes will disturb nesting raptors.

7b. An increase in the number of people in the area will result in disturbance to nesting raptors.

7c. Activities at or near ground facilities will disturb nesting raptors.

8. Disturbance at raptor nest sites will result in decreased reproductive success.

9. A decrease in reproductive success will result in a reduction of raptor populations.

Pesticide Analysis of Ptarmigan near Tuktoyaktuk and at the Mouth of the Anderson River

BREAM PROJECT OVERVIEW NO. M8-1

PRINCIPAL INVESTIGATOR:	C. Shank
AFFILIATION:	Department of Renewable Resources, N.W.T.
FUNDING SOURCE:	Unknown
EXPECTED COMPLETION DATE:	Ongoing
RELEVANT HYPOTHESIS NO.:	MEMP 8

BRIEF PROJECT DESCRIPTION

There are no data available on this project at the present time.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

The results of this study will be of indirect relevance to MEMP Hypothesis No. 8, which describes the possible effects of hydrocarbon development on raptor populations. Although linkages of this hypothesis do not deal specifically with the effects of development on the prey of raptors, any effects on ptarmigan would likely also affect raptors.

REFERENCE

Shank, C. 1991. Pesticide analysis of ptarmigan near Tuktoyaktuk and at the mouth of the Anderson River. Wildlife Management Division, Dept. Renewable Resources, GNWT, Yellowknife.

1990 Summary of Northwest Territories Raptor Project

BREAM PROJECT OVERVIEW NO. M8-2

PRINCIPAL INVESTIGATOR:	C. Shank
AFFILIATION:	Department of Renewable Resources, N.W.T.
FUNDING SOURCE:	Unknown
COMPLETION DATE:	1990
RELEVANT HYPOTHESIS NO.:	MEMP 8

BRIEF PROJECT DESCRIPTION

This report describes the results of a number of raptor surveys that were conducted in the Northwest Territories in 1990. These include one boat and two helicopter surveys, which extended along approximately 600 linear km of the Mackenzie River from Fort Norman to Inuvik, as well as a summary of raptor banding in the area. The data collected during these studies indicate that the breeding population of peregrine falcons has been productive and either stable or increasing over the past several years. A brief description of DNA analysis on peregrines and gyrfalcons is also included in this report.

On 12 May 1990, an overflight of the NWT Power Corporation's Snare hydroelectric transmission line to determine the cause of a power outage revealed the cause to be a bald eagle nest, and a July overflight found 9 poles occupied by ospreys.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL AND ASSESSMENT MONITORING PROJECT

MEMP Hypothesis No. 8 describes the possible effects of hydrocarbon development on raptor populations. Links 1 and 2 relate to the probability of nests being established on high structures, which is addressed in the above study. Ongoing raptor studies that are being conducted in the area are monitoring changes in raptor populations, which may provide useful information related to the evaluating the potential effects of hydrocarbon development.

REFERENCE

Shank, C. 1990. 1990 summary of Northwest Territories raptor project. Unpubl. MS by Wildlife Management Division, Dept. Renewable Resources, GNWT, Yellowknife. 5 p.

Numerical Changes in Two Breeding Populations of Tundra Peregrine Falcons in the Central Canadian Arctic

BREAM PROJECT OVERVIEW NO. M8-3

PRINCIPAL INVESTIGATOR:	C. Shank
AFFILIATION:	Department of Renewable Resources, N.W.T.
FUNDING SOURCE:	Unknown
COMPLETION DATE:	1990
RELEVANT HYPOTHESIS NO.:	MEMP 8

BRIEF PROJECT DESCRIPTION

Between 1982 and 1990, a number of occupied territories of tundra peregrine falcons and rough-legged hawks were monitored within two study areas (Kilgavik and Coppermine) in the Central Canadian Arctic. All of the surveys were conducted by helicopter near the time of hatch. A statistically-significant increase in the number of occupied peregrine territories was noted in both areas throughout the time period. Densities now approach those suggested as being normal for 'optimal' tundra habitat, indicating that recovery of tundra peregrine populations may be nearly complete in the Central Arctic. Superimposed over this general increase was a annual variation in the number of occupied peregrine territories associated with the number of rough-legged hawk pairs. Breeding numbers of rough-legs was strongly correlated with local microtine abundance. The authors suggest that microtine cycles probably have a small but detectable effect on the number of breeding peregrines.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

The above project is considered relevant to MEMP Hypothesis No. 8, which describes the possible effects of hydrocarbon development on raptor populations. Although this study focussed on an area outside the BREAM study region, data from undisturbed Arctic regions will provide comparative data for evaluating the potential effects of hydrocarbon development on these bird species.

REFERENCE

Shank, C., R.G. Bromley and K.G. Poole. 1991. Numerical changes in two breeding populations of tundra peregrine falcons in the Central Canadian Arctic. Unpubl. MS by Wildlife Management Division, Dept. Renewable Resources, GNWT, Yellowknife. 17 p. + tables and figures.

1990 North American Peregrine Falcon Survey, Mackenzie River Valley, Northwest Territories

BREAM PROJECT OVERVIEW NO. M8-4

PRINCIPAL INVESTIGATOR:	C. Shank
AFFILIATION:	Wildlife Management Division, Department of Renewable Resources, N.W.T.
FUNDING SOURCE:	Unknown
COMPLETION DATE:	1990
RELEVANT HYPOTHESIS NO.:	MEMP 8

BRIEF PROJECT DESCRIPTION

In June and July 1990, approximately 600 linear km of the Mackenzie River and surrounding country from 80 km upstream of Fort Norman to Inuvik were surveyed by helicopter and boat for breeding peregrine falcons. Numbers of productive nests, mean brood size and productivity per occupied territory were all higher in 1990 than those noted during a 1985 survey. Data from all five years of surveys indicate that occupancy and productivity of Mackenzie valley peregrines have improved significantly in the last decade. Banding and blood sampling for DNA analysis were also carried out in 1990.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

Information obtained during the above study will be useful in evaluating the possible effects of hydrocarbon development on raptor populations (MEMP Hypothesis No. 8).

REFERENCE

Shank, C. 1990. 1990 North American peregrine falcon survey, Mackenzie River Valley, Northwest Territories. Unpubl. MS by Wildlife Management Division, Dept. Renewable Resources, GNWT, Yellowknife. 3 p.

Gyrfalcons in the Richardson Mountains

BREAM PROJECT OVERVIEW NO. M8-5

PRINCIPAL INVESTIGATOR:	Unknown
AFFILIATION:	Canadian Wildlife Service
FUNDING SOURCE:	Unknown
EXPECTED COMPLETION DATE:	Unknown
RELEVANT HYPOTHESIS NO.:	MEMP 8

BRIEF PROJECT DESCRIPTION

There are no data available from this investigation at the present time.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

The results of this study will be of relevance to MEMP Hypothesis No. 8 in that it will provide information on raptor populations which will help to evaluate possible effects of hydrocarbon development on these populations.

REFERENCE

Shank, C. 1991. Gyrfalcons in the Richardson Mountains. Wildlife Management Division, Dep. Renewable Resources, GNWT, Yellowknife. data not available.

Yukon Gyrfalcon Project: 1987 and 1988

BREAM PROJECT OVERVIEW NO. M8-6

PRINCIPAL INVESTIGATOR:	D. Mossop
AFFILIATION:	Department of Renewable Resources, N.W.T.
FUNDING SOURCE:	Inuvialuit Final Agreement
COMPLETION DATE:	1988
RELEVANT HYPOTHESIS NO.:	MEMP 8

BRIEF PROJECT DESCRIPTION

This report describes inventory and research on gyrfalcon populations in Yukon Territory to improve the database on which management decisions could be based. The following objectives were associated with the project:

1. inventory and monitor distribution and abundance;
2. research gyrfalcon breeding ecology;
3. investigate private captive production;
4. devise wild harvest criteria; and
5. develop appropriate criteria for surveillance and control of human activities near nesting adults.

The North Slope gyrfalcon population is the Yukon's largest at about 100 pairs, with about one pair per 170 km^2. This represents an increase in abundance since 1986 when the last surveys were conducted.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

Gyrfalcon research conducted in the BREAM study area monitors changes in these populations and will be useful in assessing the effects of future hydrocarbon development. These studies are providing a useful database from which management decisions regarding harvest can be made, and the effects of disturbance can be monitored.

REFERENCE

Mossop, D. 1988. Yukon gyrfalcon project 1987 and 1988. Rep. by Yukon Dep. Renewable Resources, Whitehorse.

The Yukon Peregrine Falcon Recovery Project 1987 and 1988

BREAM PROJECT OVERVIEW NO. M8-7

PRINCIPAL INVESTIGATOR:	D. Mossop
AFFILIATION:	Department of Renewable Resources, N.W.T.
FUNDING SOURCE:	Inuvialuit Final Agreement
COMPLETION DATE:	1988
RELEVANT HYPOTHESIS NO.:	MEMP 8

BRIEF PROJECT DESCRIPTION

This report describes the results of the tenth and eleventh years of an ongoing project, which is examining the recovery of peregrine falcons in the Yukon. This is part of a Canada-wide effort to secure the species' future. Since 1977, the Yukon project has included coordinated population monitoring, captive production, release to the wild of captive-produced young, pesticide research, public education and enforcement protection.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

Peregrine falcon studies conducted in the study area monitor changes in these populations, which may be useful in assessing the effects of hydrocarbon development. The studies are providing a useful database from which management decisions concerning harvest can be made, and the effects of disturbance can be monitored.

REFERENCE

Mossop, D. 1988. The Yukon peregrine falcon recovery project 1987 and 1988. Rep. by Yukon Dep. Renewable Resources, Whitehorse.

Herschel Island Avifauna Monitoring Project

BREAM PROJECT OVERVIEW NO. M8-8

PRINCIPAL INVESTIGATOR:	D. Talarico
AFFILIATION:	Department of Renewable Resources, N.W.T.
FUNDING SOURCE:	Inuvialuit Final Agreement
COMPLETION DATE:	1988
RELEVANT HYPOTHESIS NO.:	MEMP 8 and 9

BRIEF PROJECT DESCRIPTION

The primary goals of this study were to:

1. design a methodology for annually monitoring bird populations on Herschel Island suitable to detect changes over time, notably those caused by human disturbance;
2. conduct training sessions to familiarize park rangers assigned to Herschel Island with the process designed for monitoring bird numbers;
3. conduct training sessions with Herschel Island Park Rangers in the techniques required for banding of raptors and sea birds; and
4. design and test working strategies with visitors to Herschel Island for Park Rangers to manage activities near critical nesting habitats.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

MEMP Hypothesis 8 describes the possible effects of increased disturbance and habitat alterations on raptor populations, and MEMP Hypothesis No. 9 discusses the effects of camps and garbage disposal sites on waterfowl populations. Although the above report is not directly related to hydrocarbon development, any study that monitors the effects of human access on avifauna is valuable in assessing the probable effects of human disturbance concomitant with hydrocarbon development.

REFERENCE

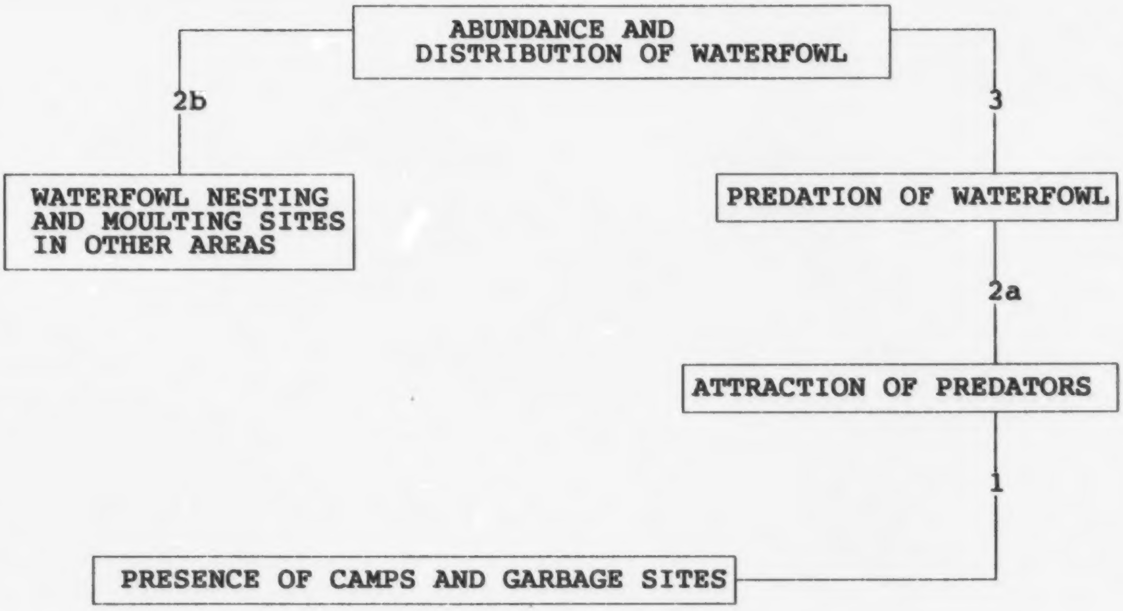
Talarico, D. and D. Mossop. 1989. Herschel Island avifauna monitoring project. Rep. by Yukon Fish. Wildl. Branch, Yukon Dep. Renewable Resources, Whitehorse. 10 p. + appendices.

OTHER RELEVANT PROJECTS

PROJECT	TITLE	PAGE
BEMP 10-3	Banks Island Bird Sanctuary No. 1 Management Plan	179
MEMP 1-4	Vegetation mapping of the Yukon Coastal Plain using Landsat thematic mapper imagery	280
MEMP 2-1	Road dust and its environmental impact on Alaskan taiga and tundra	285

MEMP HYPOTHESIS NO. 9

THE PRESENCE OF CAMPS AND GARBAGE DISPOSAL SITES WILL ATTRACT PREDATORS THAT WILL LEAD TO CHANGES IN LOCAL ABUNDANCE AND DISTRIBUTION OF WATERFOWL


ABUNDANCE AND DISTRIBUTION OF WATERFOWL
2b
3
WATERFOWL NESTING AND MOULTING SITES IN OTHER AREAS
PREDATION OF WATERFOWL
2a
ATTRACTION OF PREDATORS
1
PRESENCE OF CAMPS AND GARBAGE SITES

LINKAGES

1. The presence of camps and garbage disposal sites in an area will result in localized increases in the number of potential waterfowl predators (including bears, foxes, jaegers, gulls and ravens).

2a. Nesting or moulting waterfowl near camps and garbage disposal site will be subject to increased predation.

2b. Waterfowl nesting or moulting away from camps and garbage disposal sites will be subject to reduced predation.

3. Increased predation of nesting and moulting waterfowl near camps and garbage disposal sites will cause a decrease in the abundance and alter the distribution of waterfowl.

Bird Watching Enterprise: Pilot Trip on Yukon North Slope

BREAM PROJECT OVERVIEW NO. M9-1

PRINCIPAL INVESTIGATOR:	D. Mossop
AFFILIATION:	Yukon Dept. Renewable Resources, Fish and Wildlife Branch
FUNDING SOURCE:	Unknown
COMPLETION DATE:	1988
RELEVANT HYPOTHESIS NO.:	MEMP 9 and 22

BRIEF PROJECT DESCRIPTION

This series of reports focus on the wildlife resources of a potential wildlife viewing industry on the Yukon North Slope and on the community and local residents likely to be affected by such a project.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

MEMP Hypothesis No. 9 deals with the effects of the presence of camps and garbage disposal sites on predation rates on waterfowl. The wildlife viewing industry, although not directly linked to hydrocarbon development, can lead to similar problems of increased human/wildlife interactions, especially if camps and garbage are involved.

MEMP Hypothesis No. 22 postulates that increased wage employment in the community will alter resource harvesting activities by local residents. The wildlife viewing industry would probably employ a number of local residents, which could lead to the alteration of harvesting rates.

REFERENCE

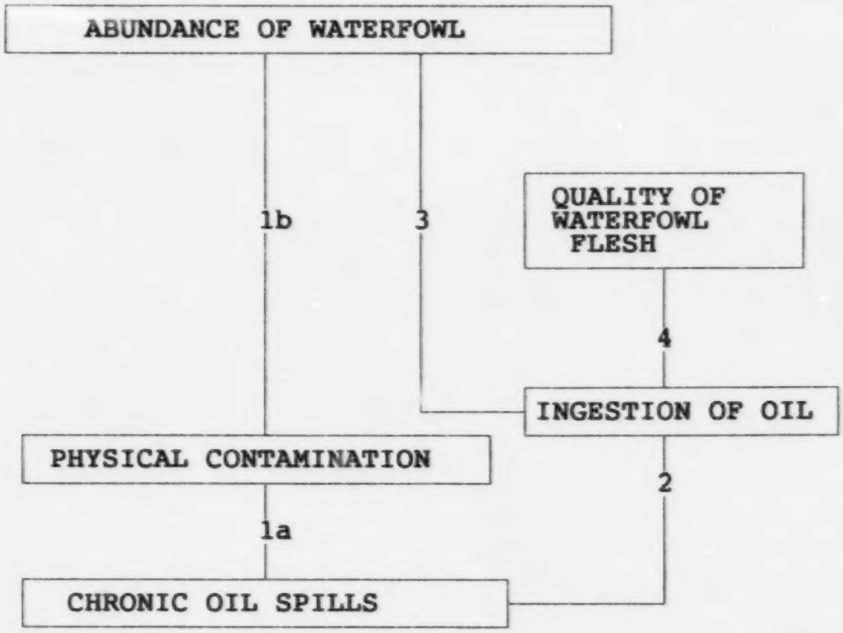
Mossop, D. and D. Talarico. 1988. Bird watching enterprise: pilot trip on Yukon North Slope. *In:* Non-consumptive wildlife use on Yukon North Slope. Rep. by Yukon Fish. Wildl. Branch, Yukon Dep. Renewable Resources, Whitehorse.

OTHER RELEVANT PROJECTS

PROJECT	TITLE	PAGE
MEMP 1-4	Vegetation mapping of the Yukon Coastal Plain using Landsat thematic mapper imagery	280
MEMP 8-8	Herschel Island avifauna monitoring project	342

MEMP HYPOTHESIS NO. 10

CHRONIC (EPISODIC) SPILLS OF CRUDE OIL AND DIESEL NEAR STAGING AND MOULTING AREAS OF NESTING COLONIES WILL REDUCE THE ABUNDANCE OF WATERFOWL



LINKAGES

1a. when susceptible bird species co-occur in space and time with the presence of an oil slick, physical contamination of the bird will occur.

1b. Mortality of waterfowl will occur following physical contamination by oil.

2. Waterfowl will consume oil through ingestion of contaminated food sources and preening of fouled plumage.

3. Mortality of waterfowl will occur if oil is ingested.

4. The quality of waterfowl flesh will be reduced if oil is ingested.

RELEVANT PROJECTS

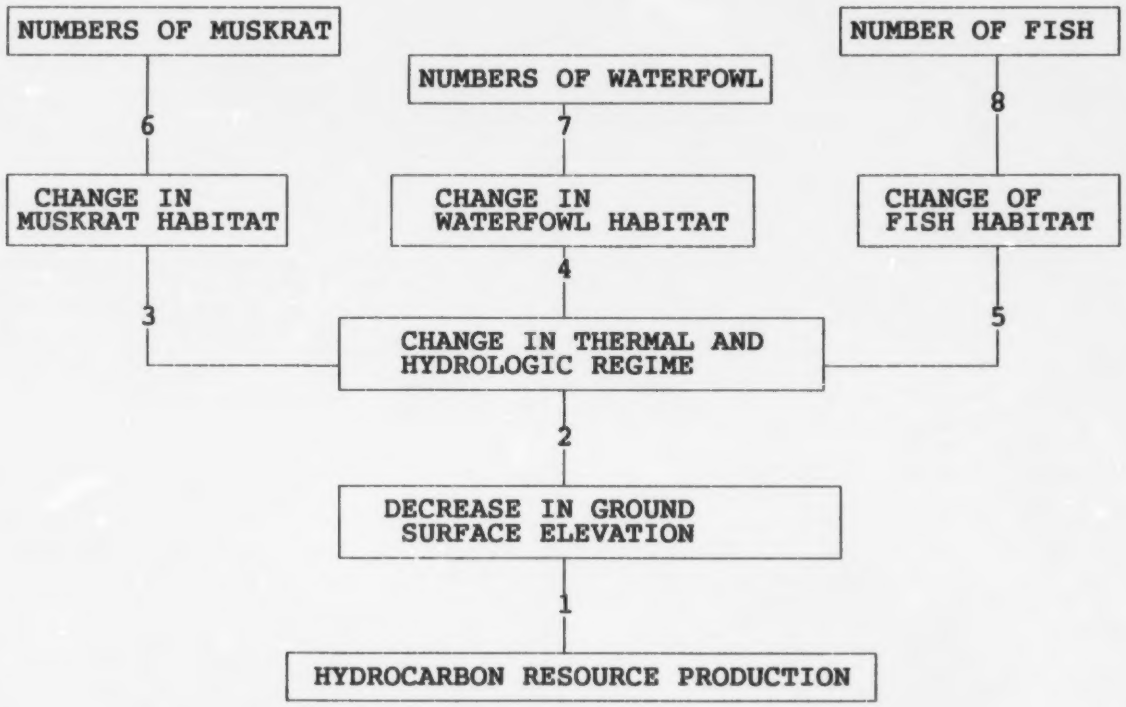
PROJECT	TITLE	PAGE
BEMP 10-2	Immediate impact of the EXXON VALDEZ oil spill on marine birds	177
BEMP 10-3	Banks Island Bird Sanctuary No. 1 Management Plan	179
BEMP 10-4	Progress report: surveys of geese and swans in the Inuvialuit Settlement Region, 1989	180
BEMP 10-5	Segregation of brant geese *Branta bernicla* wintering and staging in Puget Sound and the Strait of Georgia	181
BEMP 10-6	Wildlife and wildlife habitat restoration in the event of an oil spill in the Beaufort Sea	182
BEMP 10-7	Spring migration of eiders, oldsquaws and glaucous gulls along offshore leads of the Canadian Beaufort Sea	185
BEMP 10-8	The avifauna of Toker Point, Tuktoyaktuk Peninsula, Northwest Territories, 1985-1987	187
BEMP 10-9	Spring migration of eiders, oldsquaws and glaucous gulls along offshore leads of the Canadian Beaufort Sea	188
BEMP 10-10	Progress report on surveys of geese and swans in the Inuvialuit Settlement Region, 1988	189
BEMP 10-11	International snow goose neckbanding project - progress report	191
BEMP 10-12	Neckbanding of Arctic geese	192
BEMP 10-14	NESTUCCA oil spill: impact assessment of avian populations and habitat	194
BEMP 10-15	Distribution and abundance of waterbirds in Barkley Sound and the Long Beach/Tofino/Grice Bay area in spring 1989 following the NESTUCCA oil spill	195

RELEVANT PROJECTS (Continued)

PROJECT	TITLE	PAGE
BEMP 10-16	Foraging activity of migrating Brant at Stubbs Island in April 1989 following the NESTUCCA oil spill	195
BEMP 10-17	British Columbia seabird colony inventory: Report #4 - Scott Island. Census results from 1982 to 1989 with reference to the NESTUCCA oil spill	196
BEMP 10-18	Attendance patterns, hatching chronology and breeding population of common murres on Triangle Island, British Columbia, following the NESTUCCA oil spill	197
BEMP 12-1	Response of brant and other geese to aircraft disturbance at Izembek Lagoon, Alaska	201
BEMP 12-2	Effects of aircraft on the behavior and ecology of molting brant near Teshekpuk Lake, Alaska	201
MEMP 1-4	Vegetation mapping of the Yukon Coastal Plain using Landsat thematic mapper imagery	280
MEMP 7-5	Tundra swan and brant surveys on the Arctic coastal plain, Colville River to Staines River	329

MEMP HYPOTHESIS NO. 11

LAND SUBSIDENCE RESULTING FROM HYDROCARBON WITHDRAWAL WILL CHANGE THE ABUNDANCE AND DISTRIBUTION OF WATERFOWL, FISH AND MUSKRAT


NUMBERS OF MUSKRAT
NUMBERS OF WATERFOWL
NUMBER OF FISH
6
7
8
CHANGE IN MUSKRAT HABITAT
CHANGE IN WATERFOWL HABITAT
CHANGE OF FISH HABITAT
3
4
5
CHANGE IN THERMAL AND HYDROLOGIC REGIME
2
DECREASE IN GROUND SURFACE ELEVATION
1
HYDROCARBON RESOURCE PRODUCTION

LINKAGES

1. Hydrocarbon production will cause subsidence of the ground surface overlying the Mackenzie Delta oil and gas fields.

2. Subsidence of the ground surface will cause a change in the thermal and hydrologic regime.

3, 4 and 5 A change in the thermal and hydrologic regime will cause a change in the area and quality of habitat for muskrat (Link 3), waterfowl (Link 4) and fish (Link 5).

6, 7 and 8 A change in the area and quality of habitat will cause a change in the numbers of muskrat (Link 6), waterfowl (Link 7) and fish (Link 8).

Permafrost and Terrain Research and Monitoring: Norman Wells Pipeline
Volume I: Environmental and Engineering Considerations; Volume II: Research and Monitoring Results, 1983-1988

BREAM PROJECT OVERVIEW NO. M11-1

PRINCIPAL INVESTIGATOR:	K.L. MacInnes
AFFILIATION:	Indian and Northern Affairs Canada
FUNDING SOURCE:	INAC, NOGAP, Arctic Land Use Research Program
EXPECTED COMPLETION DATE:	Uncertain, until conditions stabilize.
RELEVANT HYPOTHESIS NO.:	MEMP 11 and 16

BRIEF PROJECT DESCRIPTION

The Norman Wells pipeline is the first completely buried oil pipeline in the discontinuous permafrost zone of northern Canada. The 869-km long pipeline, extending from Norman Wells, N.W.T. to Zama, Alberta, is located in thaw-sensitive terrain in a relatively remote part of this region and has limited seasonal access. Main pipeline construction was completed during the winters of 1983-1984 and 1984-1985. Permafrost and terrain monitoring was implemented to evaluate the impacts of pipeline construction and identify improvements for this and future projects.

Major new approaches to the design and environmental impact mitigation involved: (1) minimizing the length of pipeline in thaw-sensitive terrain; (2) minimizing the energy input from the pipeline to ice-rich terrain (small pipe; initially chilled oil); (3) locating the pipe in previously-cleared terrain; (4) retarding or preventing thaw of sensitive slopes through the use of wood chip insulation; (5) increasing the strength of the pipe by increasing the pipe grade and wall thickness; and (6) frequent monitoring and rapid response to unstable conditions such as drainage and erosion control problems.

In terms of overall pipeline performance, there have been no pipeline breaks and few pipeline exposures. Effects of construction on terrain beyond the right-of-way have been localized and short term, primarily as a consequence of prompt remedial action by Interprovincial Pipe Line Ltd. (IPL). The most pronounced effect of construction has been the widespread subsidence of material along the ditchline. Ditch subsidence has presented a persistent erosion and maintenance problem, but this has been reduced through IPL's replacement of select backfill in the ditchline. Based on interpretation of air photographs taken in July 1986, IPL estimated that approximately 30% of the ditch was visibly subsided. As general right-of-way surface subsidence continues, there will be an increasing tendency for drainage to become channelled along the right-of-way and especially in the subsided ditch, both of which will be at lower levels than surrounding terrain.

In most cases, erosion structures have performed well in limiting surface erosion of the right-of-way. However, numerous examples of small-scale erosion (gullying less than 10 cm deep) have occurred, frequently initiated by intense summer rain storms. A smaller number of erosion events have resulted in gullying to depths ranging from 20 cm to 3-4 m, and complete or partial failure of drainage control structures has occurred at several locations. Erosion has also occurred in areas where drainage control structures were not included in the original design. At several water crossings, erosion and associated disturbance of mitigation structures has occurred due to high water events and, in some cases, insufficient streambank protection. Major floods that have affected several pipeline crossings have illustrated the difficulty in predicting hydrologic regimes within the Mackenzie River.

RELATIONSHIPS AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

The monitoring of local subsidence of material along the ditchline and surface erosion at stream crossings and elsewhere along the pipeline provides information that is particularly relevant to MEMP Hypotheses Nos. 11 and 16. Changes in local drainage may also affect vegetation cover and wildlife distribution near the pipeline. Continued monitoring will provide information on the length of time required for the terrain to stabilize following construction of the pipeline.

Limnological Research on Lakes and Channels in the Mackenzie Delta and Lakes on the Tuktoyaktuk Peninsula, N.W.T.

BREAM PROJECT OVERVIEW NO. M11-2

PRINCIPAL INVESTIGATOR:	R.E. Hecky
AFFILIATION:	Department of Fisheries and Oceans, Freshwater Institute
FUNDING SOURCE:	Unknown
COMPLETION DATE:	Complete
RELEVANT HYPOTHESES NO:	MEMP 11

BRIEF PROJECT DESCRIPTION

In 1985 and 1986, a variety of studies were undertaken to examine the chemistry and limnology of lakes and channels in the Mackenzie Delta, and lakes on the Tuktoyaktuk Peninsula. These lakes are used as spawning, feeding, and rearing sites by broad whitefish, lake whitefish, arctic cisco (Delta only), and least cisco. Ice-free integral phytoplankton primary production rates were similar in the two study areas; these differences are unlikely to be an important factor causing migration of whitefish from the Mackenzie Delta to the Kukjuktuk lakes. Limnological variables showed much greater variation from 1985 to 1986 in the Kukjuktuk lakes than in the Delta lakes. The Delta lakes may have less year-to-year variability than Kukjuktuk lakes because: (1) ice-out in the Delta lakes is caused by flooding of the Mackenzie River instead of by melting of the ice, so it occurs in a narrower window of time, and (2) chemical and physical conditions in the Delta are reset to a similar starting point each year when the Mackenzie River floods. Additional reports and papers are currently being prepared.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

The results of these studies will help to understand the importance of freshwater lake habitats to migratory coregonid species. They are also of direct relevance to Links 3, 4 and 5 of MEMP Hypothesis No. 11 which relate the effect of land subsidence due to hydrocarbon extraction to the quality of aquatic habitat.

REFERENCES

Anema, C., R.E. Hecky, E.J. Fee, D. Nernberg, and S.J. Guildford. 1990. Water chemistry of some lakes and channels in the Mackenzie Delta and on Tuktoyaktuk Peninsula, N.W.T., 1985. Can. Data Rep. Fish. Aquat. Sci. 726. 73 p.

Anema, C., R.E. Hecky, S. Himmer, and S.J. Guildford. 1990. Water chemistry of some lakes and channels in the Mackenzie Delta and on Tuktoyaktuk Peninsula, N.W.T., 1986. Can. Data Rep. Fish. Aquat. Sci. 729. 63 p.

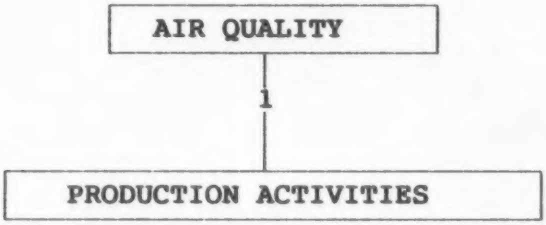
Fee, E.J., R.E. Hecky, S.J. Guildford, C. Anema, D. Mathew, K. Hallard. 1988. Phytoplankton primary production and related limnological data for lakes and channels in the Mackenzie Delta and lakes on the Tuktoyaktuk Peninsula, N.W.T. Can. Tech. Rep. Fish. Aquat. Sci. 1614. 62 p.

OTHER RELEVANT PROJECTS

PROJECT	TITLE	PAGE
BEMP 1-3	The distribution of nutrients in the southeastern Beaufort Sea: implications for water circulation and primary production	87
BEMP 1-4	Production studies in the Mackenzie River-Beaufort Sea estuary	88
BEMP 1-5	Ecological factors governing the distribution and abundance of the copepod, *Limnocalanus macrurus*, in the Beaufort Sea	90
BEMP 1-6	Zooplankton and bowhead whale feeding in the Canadian Beaufort Sea, 1986	92
BEMP 1-7	Zooplankton of a bowhead whale feeding area off the Yukon coast in August 1985	94
BEMP 1-10	Zooplankton distributions in the southeastern Beaufort Sea summer 1987	99
BEMP 1-11	Distribution and life history of *Limnocalanus macrurus*, an estuarine copepod, in the Beaufort Sea	101
MEMP 1-4	Vegetation mapping of the Yukon Coastal Plain using Landsat thematic mapper imagery	280

MEMP HYPOTHESIS NO. 12

AIR EMISSIONS RESULTING FROM OIL AND GAS DEVELOPMENT AND OPERATION WILL ADVERSELY AFFECT AIR QUALITY



LINKAGE

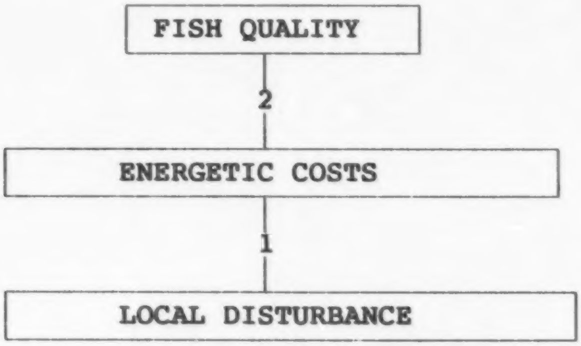
1. Air emissions from a number of sources will adversely affect air quality.

RELEVANT PROJECTS

PROJECT	TITLE	PAGE
—	No other Project Overviews are directly relevant to MEMP Hypothesis No. 12	—

MEMP HYPOTHESIS NO. 13

INCREASED LOCAL DISTURBANCE DUE TO ACTIVITIES RELATED TO HYDROCARBON DEVELOPMENT WILL RESULT IN DECREASES IN FISH QUALITY



LINKAGES

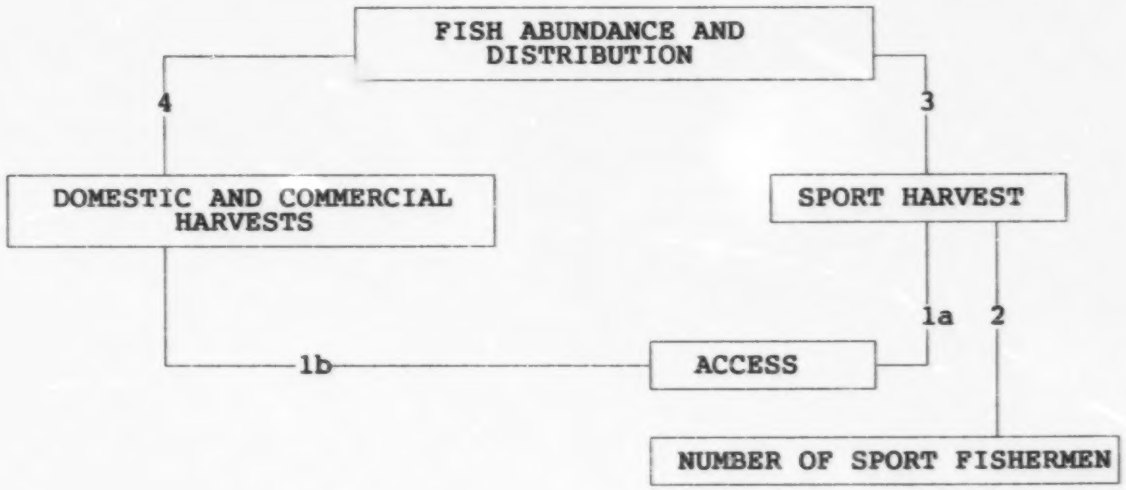
1. Increased local disturbance (e.g. from additional barge traffic) will result in energetic costs to fish in the areas of disturbance.
2. Higher energy expenditure will result in decreased fish quality.

RELEVANT PROJECTS

PROJECT	TITLE	PAGE
BEMP 14-8	Fisheries research in the Mackenzie Valley	240

MEMP HYPOTHESIS NO. 14

IMPROVED ACCESS AND FISHING PRESSURE WILL DECREASE THE ABUNDANCE OF FISH AND AFFECT THEIR DISTRIBUTION


FISH ABUNDANCE AND DISTRIBUTION
4
3
DOMESTIC AND COMMERCIAL HARVESTS
SPORT HARVEST
1a
2
1b
ACCESS
NUMBER OF SPORT FISHERMEN

LINKAGES

1. Improved access will increase sport, commercial and domestic harvests of fish.
2. The number of recreational fishermen will increase due to industrial development; this will increase harvests of sport fish.
3. Increased sport harvest will reduce local and regional populations of sport fish.
4. Increased domestic and commercial harvests will reduce local and regional populations of fish, and alter their distribution.

Charr Stock Differentiation

BREAM PROJECT OVERVIEW NO. M14-1

PRINCIPAL INVESTIGATOR: J.D. Reist
AFFILIATION: Department of Fisheries and Oceans, Freshwater Institute
FUNDING SOURCES: DFO and NOGAP
EXPECTED COMPLETION DATE: Unknown
RELEVANT HYPOTHESIS NO.: MEMP 14 and 16

BRIEF PROJECT DESCRIPTION

This study was initiated in 1986 to: (1) determine the discreteness and number of charr stocks in the western Arctic using morphometric, meristic and electrophoretic techniques; and (2) establish the relatedness of these populations. In 1990, a supplementary project was initiated to investigate the population dynamics of early life history stages.

Charr were sampled at sites on Joe and Cache creeks and on the Firth, Babbage, Canoe, and Rat rivers. The allele frequencies of different stages of anadromous fish and of fish with anadromous or residual stream-resident life histories did not differ significantly. Stream-resident fish that were physically isolated from anadromous and residual stream-resident populations had allele frequencies that were significantly different from anadromous fish. Allele frequencies were different among populations in different river basins and tributaries. It was concluded that charr in this region are structured into genetic stocks and that these stocks retain their fidelity to at least some rivers during all life history stages.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This study is of relevance to all hypotheses that deal with Arctic charr and the management and protection strategies that will be required in a development setting.

REFERENCE

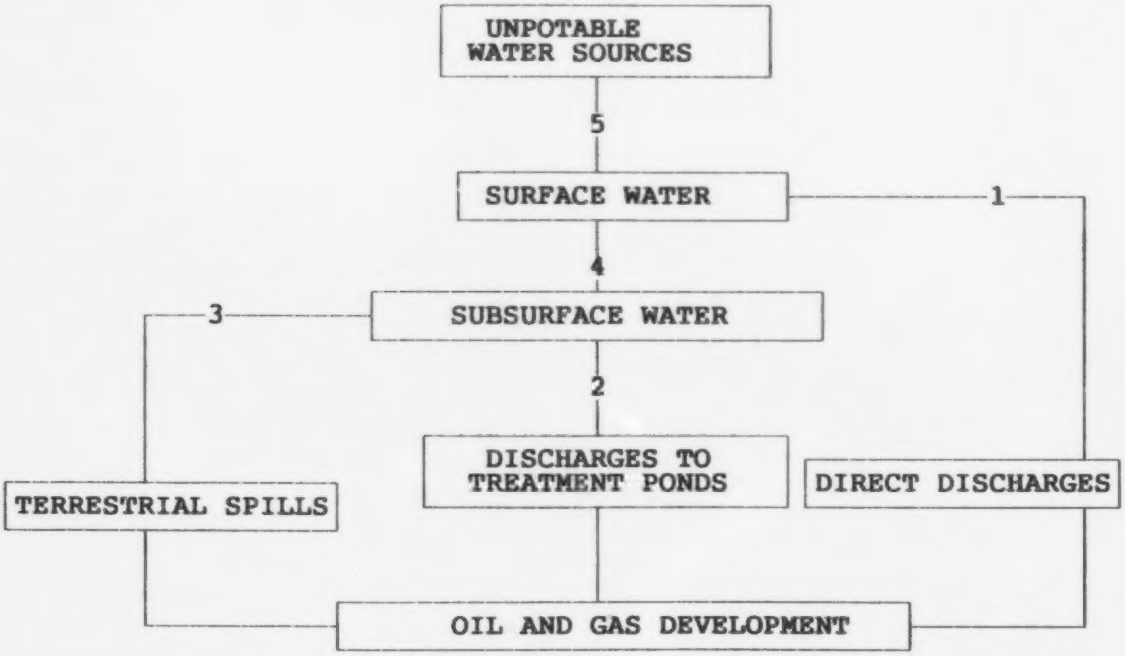
Reist, J. 1989. Genetic structuring of allopatric populations and sympatric life history types of charr, *Salvelinus alpinus/malma*, in the western Arctic, Canada. Physio. Ecol. Japan, Spec. Vol. 1: 405-420.

OTHER RELEVANT PROJECTS

PROJECT	TITLE	PAGE
BEMP 14-1	Broad whitefish stock differentiation	233
BEMP 14-2	Identification of coregonids	234
BEMP 14-3	Hybridization of coregonids	235
BEMP 14-4	External scarring of whitefish, *Coregonus nasus* and *C. clupeaformis* complex, from the western Northwest Territories, Canada	236
BEMP 14-5	Broad whitefish population dynamics	237
BEMP 14-8	Fisheries research in the Mackenzie Valley	240
BEMP 15-1	Arctic cisco migrations and life history	243
BEMP 15-2	Coastal migrations of Arctic cisco	244
BEMP 15-3	Arctic cisco stock differentiation	245
MEMP 1-5	Native harvest surveys and statistics: a critique of their construction and use	281

MEMP HYPOTHESIS NO. 15A

WASTE DISCHARGE AND ACCIDENTAL OIL/CHEMICAL SPILLS WILL LEAD TO UNPOTABLE WATER



LINKAGES

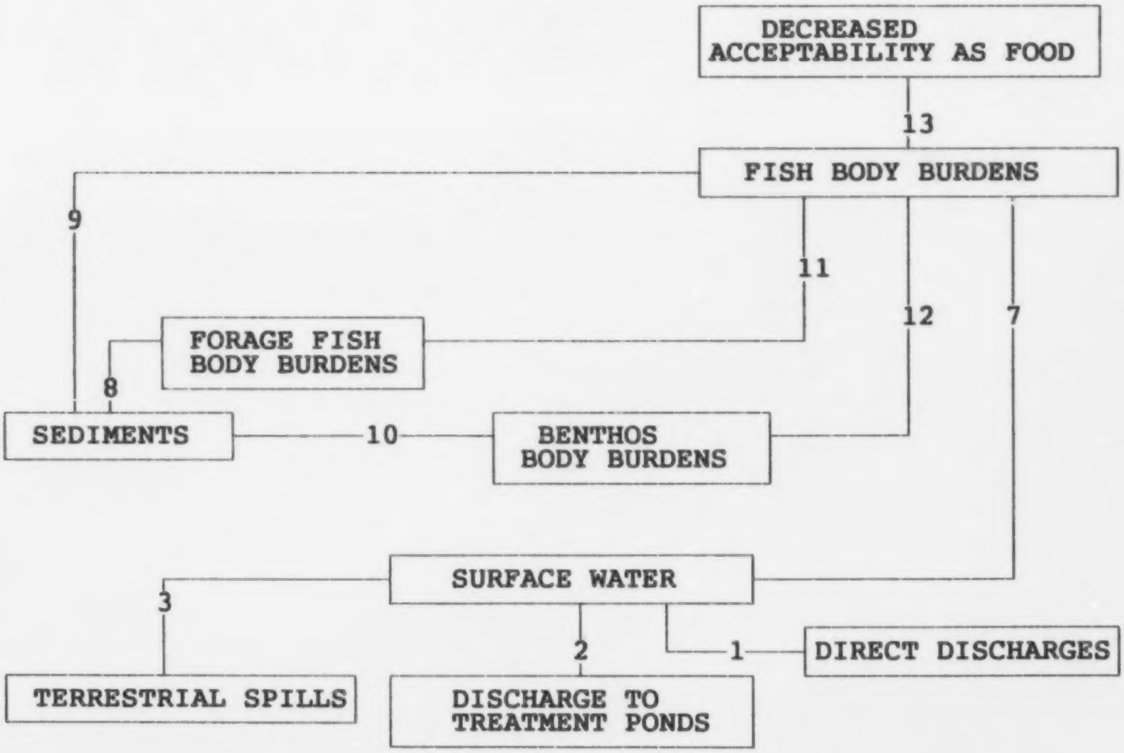
1. Direct discharges of contaminants to rivers, streams and lakes will increase their concentrations in water.
2. Discharges of contaminants to treatment ponds will lead to increased contaminant concentrations in subsurface water.
3. Terrestrial spills of contaminants will lead to increased contaminant concentrations in subsurface water.
4. Increased concentrations of contaminants in subsurface water will result in increased concentrations of these elements or compounds in surface water.
5. Increased contaminant concentrations in surface water will lead to a decrease in the potability of water sources.

RELEVANT PROJECTS

PROJECT	TITLE	PAGE
—	No other Project Overviews are directly relevant to MEMP Hypothesis No. 15A	—

MEMP HYPOTHESIS NO. 15B

WASTE DISCHARGE AND ACCIDENTAL OIL/CHEMICAL SPILLS WILL LEAD TO DECREASED ACCEPTABILITY OF FISH AS A FOOD SOURCES



LINKAGES

1. Direct discharges of contaminants into rivers, streams and lakes will increase their concentrations in water.

2. Discharges of contaminants to treatment ponds will lead to increased contaminant concentrations in subsurface water.

3. Terrestrial spills will lead to increased contaminant concentrations in subsurface water.

4. Increased concentrations of contaminants in subsurface water will result in increased contaminant concentrations in surface water.

6. Increased contaminant concentrations in surface water will result in increased contaminant concentrations in sediments.

7. Increased contaminant concentrations in surface water will lead to contaminant uptake by fish.

8. Increased contaminant concentrations in surface water will lead to increased contaminant body burdens in forage fish.

9. Increased contaminant concentrations in sediments will lead to increased contaminant body burdens in bottom-feeding fish.

10. Increased contaminant concentrations in sediments will lead to increased contaminant body burdens in benthic fauna.

11. Increased contaminant body burdens in forage fish will lead to increased body burdens in predatory fish.

12. Increased contaminant body burdens in benthos will lead to increased body burdens in bottom-feeding fish.

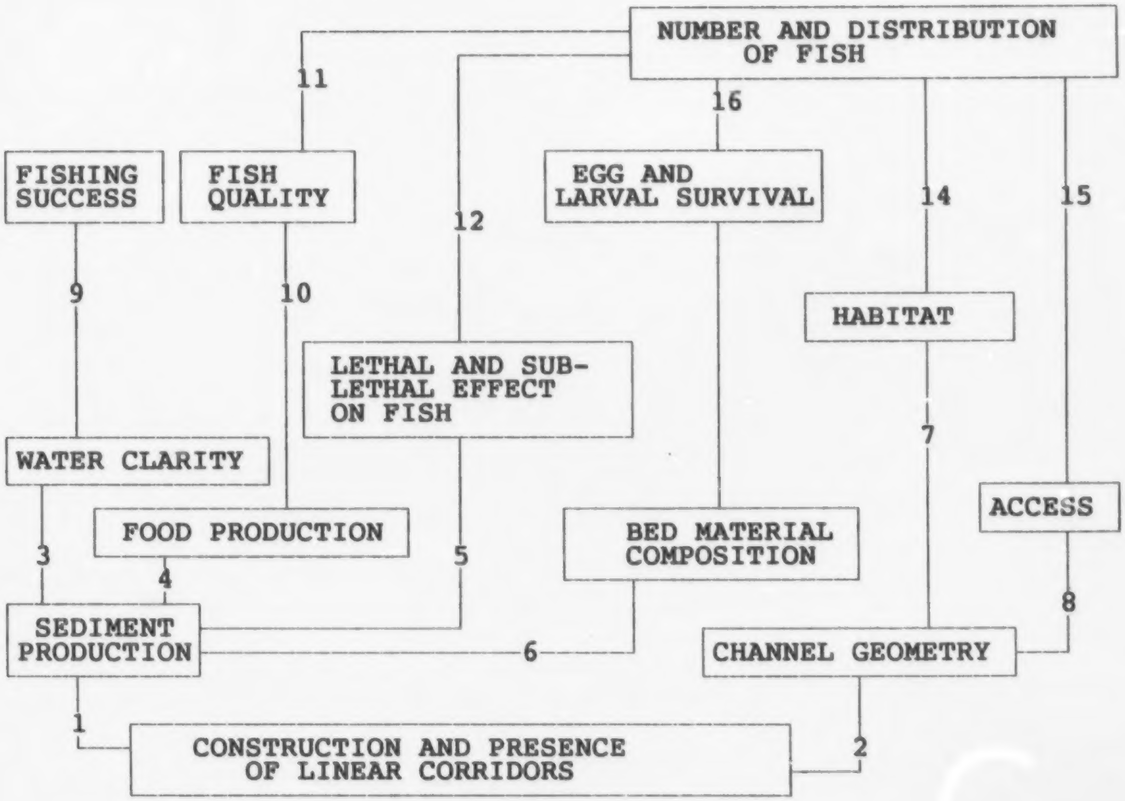
13. Increased contaminant body burdens in fish will lead to decreased acceptability of fish as a food source by local residents.

RELEVANT PROJECTS

PROJECT	TITLE	PAGE
BEMP 13-1	Studies on the condition of fish and hydrocarbon exposure	206
BEMP 13-7	Geochemistry and fluxes of hydrocarbons to the Beaufort Sea shelf	214
BEMP 13-10	The flux of suspended particulates, petroleum-related hydrocarbons, trace metals and nutrients from the Mackenzie River during the winter season: A pilot study of the East Channel	218
BEMP 13-13	MFO induction measurement	222

MEMP HYPOTHESIS NO. 16

THE CONSTRUCTION AND PRESENCE OF LINEAR CORRIDORS WILL AFFECT THE NUMBER, DISTRIBUTION AND QUALITY OF FISH, AND FISHING SUCCESS



LINKAGES

1. Construction and operation of linear corridors will increase rates of sediment production at specific locations or over large areas.

2. Construction activities will alter channel geometry at specific locations.

3. Increased rates of sediment production at specific locations will decrease water clarity.

4. Increased rates of sediment production at specific locations will decrease the abundance or availability of prey species.

5. Increased suspended sediment concentrations and exposure durations will have lethal and sublethal effects on fish and change their behaviour patterns.

6. Local changes in sediment production will affect streambed material size.

7. Alterations in channel morphology will directly affect the extent or distribution of in-stream habitat at specific locations.

8. Local changes in channel geometry or thermal regime will result in blockage of fish movement.

9. Local decreases in water clarity will decrease angling success and increase net fishing success.

10. Local decreases in the production of prey organisms will reduce the size and quality of fish.

11. Local decreases in the production of prey organisms will result in fish mortality or changes in their distribution.

12. Fish avoidance, attraction or migrations due to high suspended sediment concentrations will affect the number of distribution of fish.

13. Increased concentrations of fine-textured materials within the river bed will reduce egg and larval fish survival.

14. Local changes in the amount and quality of habitat will change the number of distribution of fish.

15. Local restrictions in access will reduce spawning or rearing success and overwinter survival and, therefore, affect the number and distribution of fish.

16. Local decreases in fish egg and larval survival rates will reduce numbers and later the distribution of fish.

Evaluation of Logjam Clearing Operations at Keneksek Creek

BREAM PROJECT OVERVIEW NO. M16-1

PRINCIPAL INVESTIGATOR:	K.T.J. Chang-Kue
AFFILIATION:	Department of Fisheries and Oceans, Freshwater Institute
FUNDING SOURCE:	DFO and NOGAP
EXPECTED COMPLETION DATE:	Unknown
RELEVANT HYPOTHESIS NO.:	MEMP 16

BRIEF PROJECT DESCRIPTION

The objectives of this study were to evaluate the effectiveness of logjam clearing and determine whether blockage to fish migrations occurred in the mouth/estuary of Kenesek Creek. Logjams were cleared in September 1986, and the site was inspected in 1987 after the spring freshet and during mid summer low-flow conditions. Ten broad whitefish were radio tagged in mid July 1987 and their locations and fate tracked.

Because debris from channel clearing had not been moved to high ground, spring floods resulted in several small blockages by June 1987. By mid July, fish passage was impossible and radio-tagged fish remained trapped in the stream until August. In August, a storm surge obliterated the cut channel and essentially returned the logjam to its original state. The storm surge allowed tagged fish to escape the stream and proceed westwards to Whitefish Bay, a known coastal overwintering site. It was concluded that passage into the system was possible for foraging fish in spring. In summer, low flows generally prevented return migrations to the coast, but high tides accompanying coastal storms will allow escape. Fish unable to return would most likely overwinter in the headwaters.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

This work provides information concerning the potential for natural stream blockages to interfere with broad whitefish migrations, as well as the potential for enhancement of stream habitat to improve fish passage.

OTHER RELEVANT PROJECTS

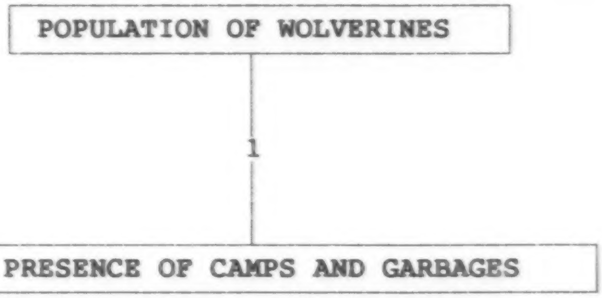
PROJECT	TITLE	PAGE
BEMP 1-3	The distribution of nutrients in the southeastern Beaufort Sea: implications for water circulation and primary production	86
BEMP 1-4	Production studies in the Mackenzie River-Beaufort Sea estuary	88
BEMP 1-5	Ecological factors governing the distribution and abundance of the copepod, *Limnocalanus macrurus*, in the Beaufort Sea	90
BEMP 1-6	Zooplankton and bowhead whale feeding in the Canadian Beaufort Sea, 1986	92
BEMP 1-7	Zooplankton of a bowhead whale feeding area off the Yukon coast in August 1985	94
BEMP 1-10	Zooplankton distributions in the southeastern Beaufort Sea summer 1987	99
BEMP 1-11	Distribution and life history of *Limnocalanus macrurus*, an estuarine copepod, in the Beaufort Sea	101
BEMP 14-2	Identification of coregonids	234
BEMP 14-3	Hybridization of coregonids	235
BEMP 14-4	External scarring of whitefish, *Coregonus nasus* and *C. clupeaformis* complex, from the western Northwest Territories, Canada	236
BEMP 14-5	Broad whitefish population dynamics	237
BEMP 14-7	Overwintering fish habitat in the nearshore Beaufort and Mackenzie Delta	239
BEMP 15-3	Arctic cisco stock differentiation	245
MEMP 1-4	Native harvest surveys and statistics: a critique of their construction and use	280

OTHER RELEVANT PROJECTS (Continued)

PROJECT	TITLE	PAGE
MEMP 5-1	Long-term success of seeded species and their influence on native species invasion at abandoned Rig Site A-01, Caribou Hills, N.W.T.	310
MEMP 5-2	Revegetation monitoring of the Interprovincial Pipe Line (NW) Ltd. Norman Wells to Zama pipeline	311
MEMP 11-1	Permafrost and terrain research and research and monitoring: Norman Wells Pipeline Volume I: Environmental and engineering considerations; Volume II: Research and monitoring results, 1983-1988	354
MEMP 14-1	Charr stock differentiation	362

MEMP HYPOTHESIS NO. 17

WOLVERINES ATTRACTED TO CAMPS AND GARBAGE WILL BE KILLED AS NUISANCE ANIMALS, THUS REDUCING THE POPULATION



LINKAGE

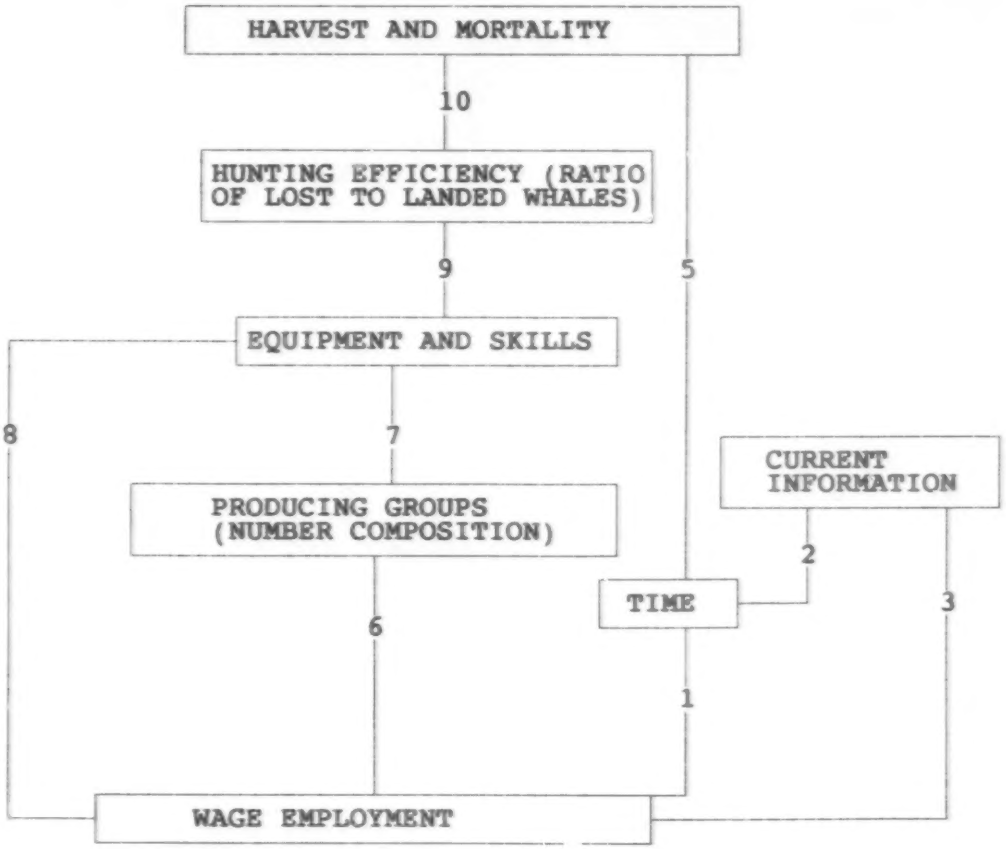
1. Wolverines attracted to camps and garbage will be killed as nuisance animals, thus reducing the population.

RELEVANT PROJECTS

PROJECT	TITLE	PAGE
—	No other Project Overviews are directly relevant to MEMP Hypothesis No. 17	—

MEMP HYPOTHESIS NO. 18

WAGE EMPLOYMENT WILL CHANGE THE HARVEST OF WHITE WHALES



LINKAGES

1. Wage employment of Mackenzie Delta residents will result in less time available for hunting and thereby reduce native hunting effort.

2. Reduced hunting effort will decrease the amount of new information obtained each year concerning the distribution and availability of white whales.

3. Wage employment will affect the current level of information by changing the travelling routes and living areas of natives.

4. A change in the current level of information will affect the harvest.

5. Reduced hunting effort will decrease the number of whales taken and/or change the age/sex composition of the harvest.

6. Wage employment will alter the number and/or the composition of harvesting groups.

7. A change in the number and/or the composition of harvesting groups will decrease the general level of skills and change the quality of equipment used by hunters.

8. Wage employment will change the quality of the equipment used by hunters.

9. Less skillful hunters and a change in the quality of equipment used will reduce hunter efficiency (i.e., increase the ratio of lost to landed whales).

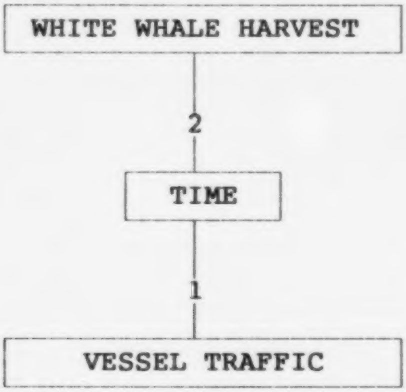
10. An increase in the ratio of lost to landed whales will increase white whale mortality.

RELEVANT PROJECTS

PROJECT	TITLE	PAGE
BEMP 2-4	Inuvialuit harvest study	140
BEMP 2-7	Beluga harvest monitoring, 1988, 1989 and 1990	143
MEMP 1-5	Native harvest surveys and statistics: a critique of their construction and use	281

MEMP HYPOTHESIS NO. 19

VESSEL TRAFFIC WILL DECREASE THE HARVEST OF WHITE WHALES



LINKAGES

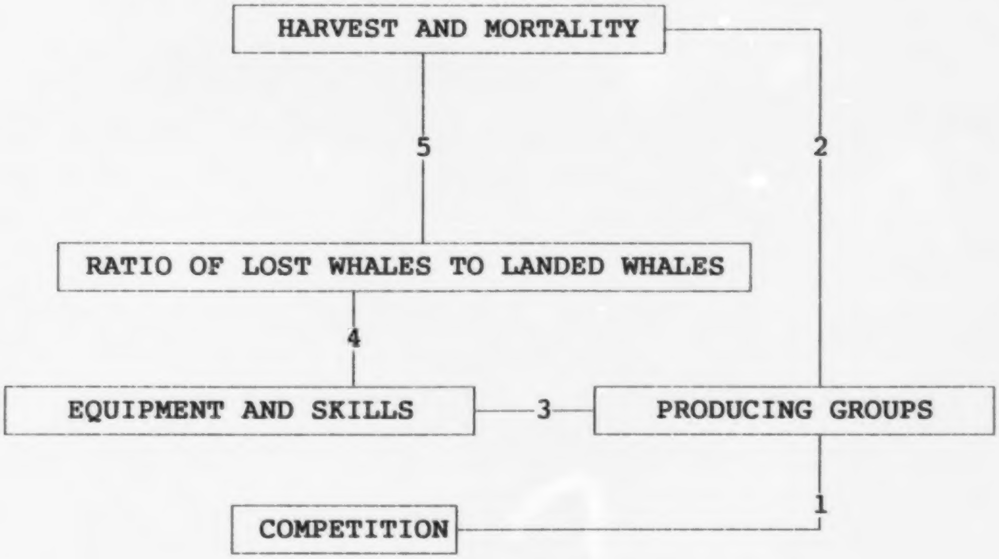
1. Vessel traffic will reduce the time available for hunting by directly interfering with hunting activities.
2. Less time available for hunting will result in a decrease in the harvest of white whales.

RELEVANT PROJECTS

PROJECT	TITLE	PAGE
BEMP 2-4	Inuvialuit harvest study	140
BEMP 2-6	The Canadian Oil and Gas Lands Administration Annual Reports 1988 and 1989	141
BEMP 2-7	Beluga harvest monitoring, 1988, 1989 and 1990	143
MEMP 1-5	Native harvest surveys and statistics: a critique of their construction and use	281

MEMP HYPOTHESIS NO. 20

COMPETITION BY NON-LOCALS WILL CHANGE NUMBER OF WHITE WHALES LANDED AND INCREASE MORTALITY IN THE POPULATION



LINKAGES

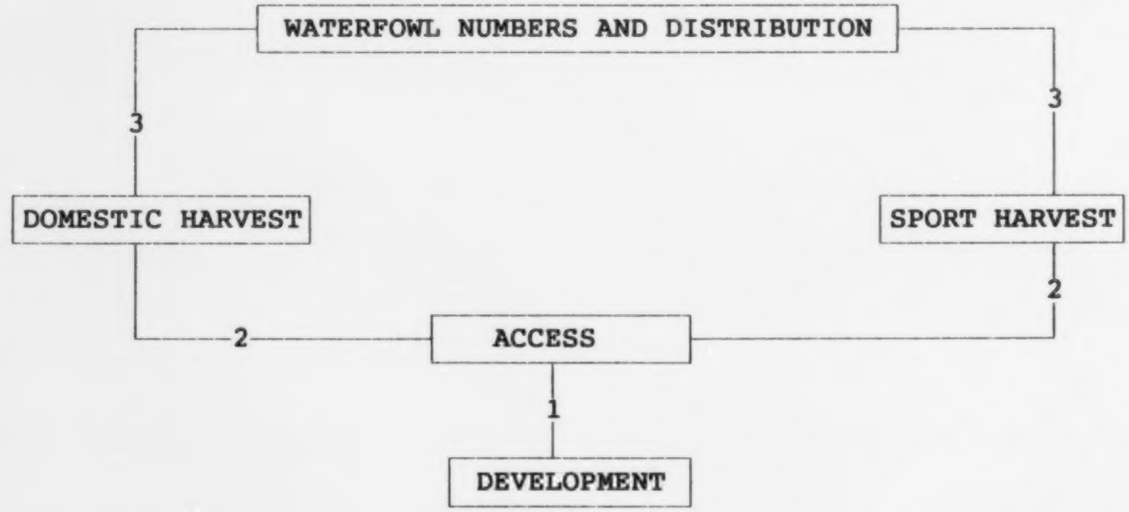
1. Competition will increase the number of, and alter the composition of the harvesting groups if both local and non-local hunters are involved in the harvest.
2. An increase in the number of harvesting groups will increase the harvest and mortality of white whales.
3. Inexperienced, non-local hunters will have less skill than local hunters, as well as incomplete or inappropriate equipment.
4. Less skillful and effective hunters, in conjunction with incomplete or inappropriate equipment, will increase the ratio of lost to landed whales.
5. An increase in the ratio of lost to landed whales will cause an increase in white whale mortality.

RELEVANT PROJECTS

PROJECT	TITLE	PAGE
MEMP 1-5	Native harvest surveys and statistics: a critique of their construction and use	281

MEMP HYPOTHESIS NO. 21

INCREASED OR IMPROVED ACCESS ASSOCIATED WITH HYDROCARBON DEVELOPMENT WILL INCREASE THE HARVEST OF WATERFOWL, WHICH WILL LEAD TO A REDUCTION IN THE NUMBER AND ALTER THE DISTRIBUTION OF WATERFOWL



LINKAGES

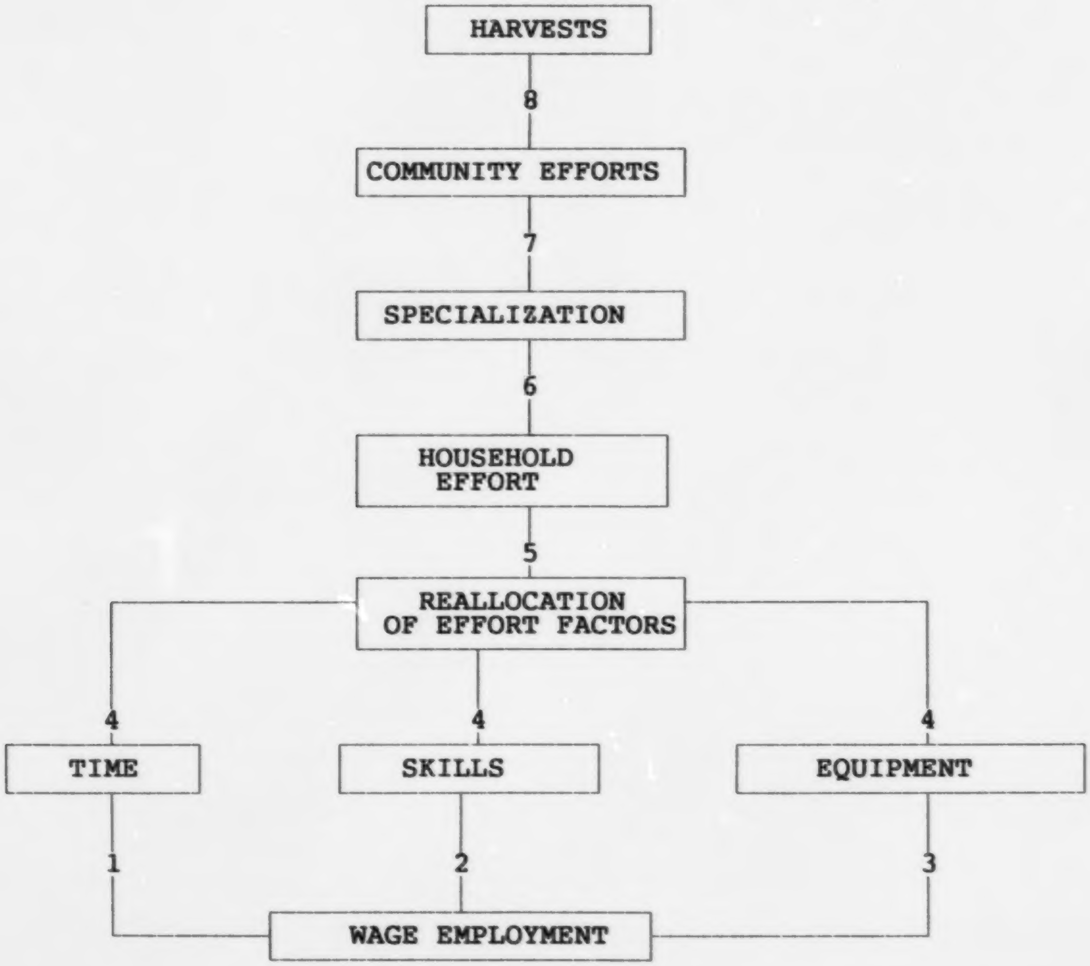
1. Hydrocarbon development will result in increased or improved access to areas supporting waterfowl populations.
2. Increased or improved access will increase the harvest of waterfowl.
3. Increased harvest will lead to reductions in local populations of waterfowl.

RELEVANT PROJECTS

PROJECT	TITLE	PAGE
BEMP 2-4	Inuvialuit harvest study	140
MEMP 1-5	Native harvest surveys and statistics: a critique of their construction and use	281

MEMP HYPOTHESIS NO. 22

INCREASED LEVELS OF WAGE EMPLOYMENT WILL CHANGE THE TOTAL ANNUAL HARVESTS OF RESOURCES BY COMMUNITIES IN THE REGION



LINKAGES

1. Wage employment reduces the time available for harvesting.
2. Wage employment decreases or delays opportunities to learn harvesting skills.
3. Income from wage employment enables expansion and improvement of the supply of harvesting equipment.
4. The allocation of effort employed by both individual units of production and related sets of units will change.
5. total effort on the part of individual and/or related sets of producing units will change.
6. Substitution and reallocation of effort factors will affect both the numbers of producing units in a community and their degree of specialization.
7. Specialization among producing units results in a reallocation of effort and a change in the total community harvesting effort.
8. The level of effort is positively related to the volume of harvest.

Harvest Study - South of Inuvialuit Settlement Region

BREAM PROJECT OVERVIEW NO. M22-1

PRINCIPAL INVESTIGATOR:	Unknown
AFFILIATION:	DFO and FJMC
FUNDING SOURCE:	Fisheries Joint Management Committee/Department Fisheries and Oceans
COMPLETION DATE:	1988
RELEVANT HYPOTHESIS NO.:	MEMP 22 and 24

BRIEF PROJECT DESCRIPTION

The study is designed to compliment the Inuvialuit Harvest Study (BREAM Project Overview No. B2-4), providing information on harvest levels of fish outside but adjacent to the Inuvialuit Settlement Region. The domestic harvest was monitored in the Arctic Red River and Fort McPherson area of the Mackenzie River watershed.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

While the study is designed to compliment the Inuvialuit Harvest Study, it serves to expand the fish harvest data base. As such, the data base can be used to further study the relationships of harvest and wage employment, and conflicts between land users resulting from industrial activity.

Data Report Based on Information Collected in 1981 during a Survey of the Domestic Fishery in the Mackenzie Delta Area, Northwest Territories

BREAM PROJECT OVERVIEW NO. M22-2

PRINCIPAL INVESTIGATOR:	Sparling and Sparling
AFFILIATION:	Sparling Consulting
FUNDING SOURCE:	Fisheries Joint Management Committee
COMPLETION DATE:	1988
RELEVANT HYPOTHESIS NO.:	MEMP 22, 23 and 24

BRIEF PROJECT DESCRIPTION

Although this research was completed in 1981, a report was not released until mid 1988. From a literature review conducted by the Department of Fisheries and Oceans, it was determined that there were major gaps in the data base in terms of type and amount of equipment, gear used, effort expended and the catch of the each species in the domestic fishery. The report summarizes the results of a survey conducted from June through November of 1981 to assess the domestic fishing effort and harvest in the Mackenzie River Delta.

In the report, the author cites that "ongoing commercial efforts, increasing regional human populations and natural resource development activities in the delta region and upstream in the Mackenzie watershed, have created concern for possible adverse effects on the domestic fish harvest within the Delta."

Data were obtained through: (1) interviews with domestic fishermen from Aklavik, Inuvik, Fort Macpherson and Arctic Red River; (2) enumeration and biological sampling of fish from gillnet catches; and (3) catch-effort determinations by species. The report describes the fishery in the context of its physical environment on a portion of the Delta approximately 210 km long by 65 km wide, and the diversity of species. The interviews provided data on harvest catch utilization, fishing methods, fishing seasons, and fishing effort. This information was integrated and an estimate of the harvest by major species presented.

Results of the biological investigation (age, weight, size and maturity) were summarized for five distinct geographic areas (generally representative of a particular community fishing area) and the Mackenzie Delta as a whole.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

The study was designed to reduce the gaps in the information base related to the domestic fishery in the Mackenzie Delta. This information base combined with the ongoing Inuvialuit Harvest Study by the Fishery Joint Management Committee can be used in planning for the use and management of resources. The information can be used in further testing the validity of the hypotheses that relate to possible conflicts between industry and harvesters over land use, changes in access and increased levels of wage employment causing changes to the total annual harvests.

Individual Trapping - Record Summary

BREAM PROJECT OVERVIEW NO. M22-3

PRINCIPAL INVESTIGATOR:	R. Hall
AFFILIATION:	Department of Renewable Resources (Fur Management), N.W.T.
FUNDING SOURCE:	Department of Renewable Resources, N.W.T.
EXPECTED COMPLETION DATE:	Ongoing
RELEVANT HYPOTHESIS NO.:	MEMP 22, 23 and 24

BRIEF PROJECT DESCRIPTION

This project is ongoing and fine-fur harvest data are currently being compiled for 1990. Summary reports provide an overview, by community, of the number of General Hunting Licence trappers who reported fur harvests to the Department of Renewable Resources. The report quantifies harvest of fine-fur species and their economic value to the harvester. The data are summarized for each Government of the Northwest Territories region and for the entire N.W.T. Standardized data reports are available for previous years.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

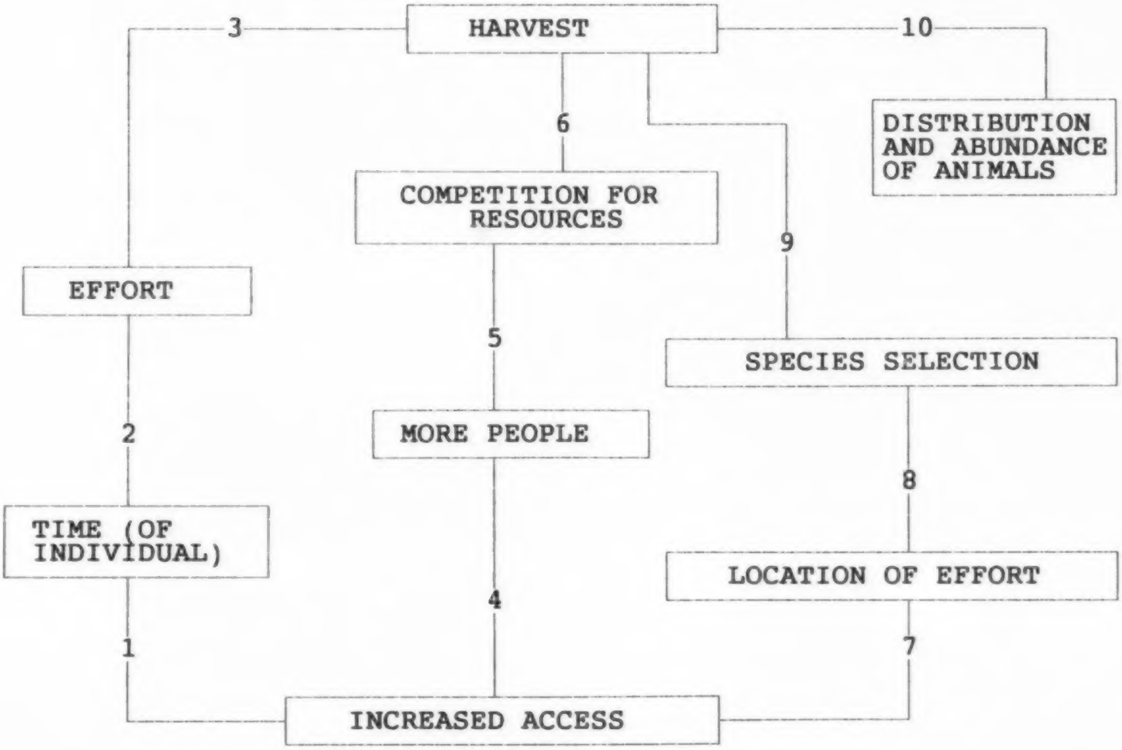
These annual reports provide a database of fine-fur harvests on a community-by-community basis. The data have been standardized over the years, and annual comparisons demonstrating trends in the number of trappers, volume by species and aggregate prices paid by species can now be made. The reports are relevant to MEMP Hypotheses Nos. 22, 23, and 24 in that they provide a historical database that will be important in further evaluation of these impact hypotheses.

OTHER RELEVANT PROJECTS

PROJECT	TITLE	PAGE
BEMP 2-4	Inuvialuit harvest study	140
MEMP 1-5	Native harvest surveys and statistics: a critique of their construction and use	281
MEMP 9-1	Bird watching enterprise: pilot trip on Yukon North Slope	346

MEMP HYPOTHESIS NO. 23

CHANGES IN ACCESS WILL AFFECT THE HARVEST OF BIRDS, FISH AND MAMMALS



LINKAGES

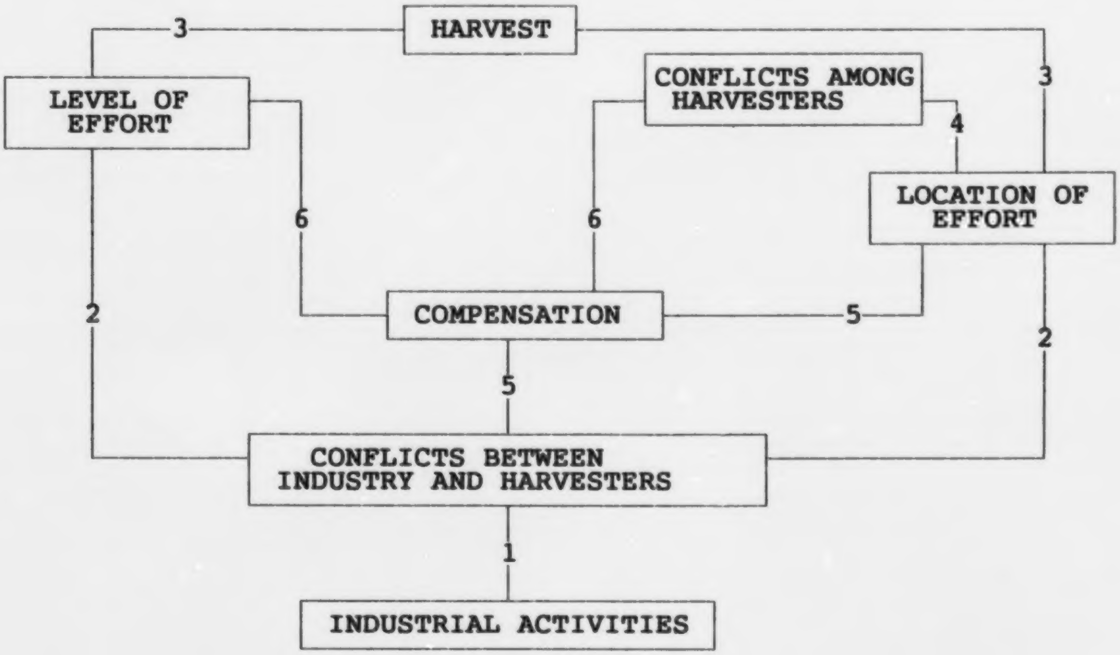
1. Changes in access will decrease the time spent in harvesting activities by an individual harvester.
2. Decreases in travel time will affect the level of effort or catch per unit of effort.
3. Changes in the level of effort will change harvests.
4. Increased access to an area results in increased use of the area.
5. An increase in the number of people using an area for hunting and trapping will result in competition among them for limited resources.
6. Competition for resources will affect harvests.
7. Increased access changes the locations at which harvesting effort is applied.
8. Changes in the location of effort may result in changes in the species harvested.
9. Changes in species selection will influence harvests.
10. Harvest changes as a result of increased access may affect the distribution and abundance of animals locally or regionally.

RELEVANT PROJECTS

PROJECT	TITLE	PAGE
BEMP 2-3	A draft community-based Regional Land Use Plan for the Mackenzie Delta-Beaufort Sea region	139
BEMP 2-4	Inuvialuit harvest study	140
MEMP 1-5	Native harvest surveys and statistics: a critique of their construction and use	281
MEMP 22-2	Data report based on information collected in 1981 during a survey of the domestic fishery in the Mackenzie Delta area, Northwest Territories	387
MEMP 22-3	Individual trapping - record summary	388

MEMP HYPOTHESIS NO. 24

INDUSTRIAL ACTIVITIES IN HARVESTING AREAS WILL REDUCE THE HARVESTS OF MAMMALS, BIRDS AND FISH BECAUSE OF CONFLICTS BETWEEN INDUSTRY AND HARVESTERS OVER LAND USE



LINKAGES

1. Industrial activities will result in conflicts between industry and harvesters.

2. Conflicts between industry and harvesters will result in the alienation of land from resource harvesting on a temporary or permanent basis.

3. Changes in location and level of effort of some harvesters will reduce both individual and community harvests.

4. Harvesters will move into someone else's harvesting area and come into conflict and compete with harvesters who are already using the area.

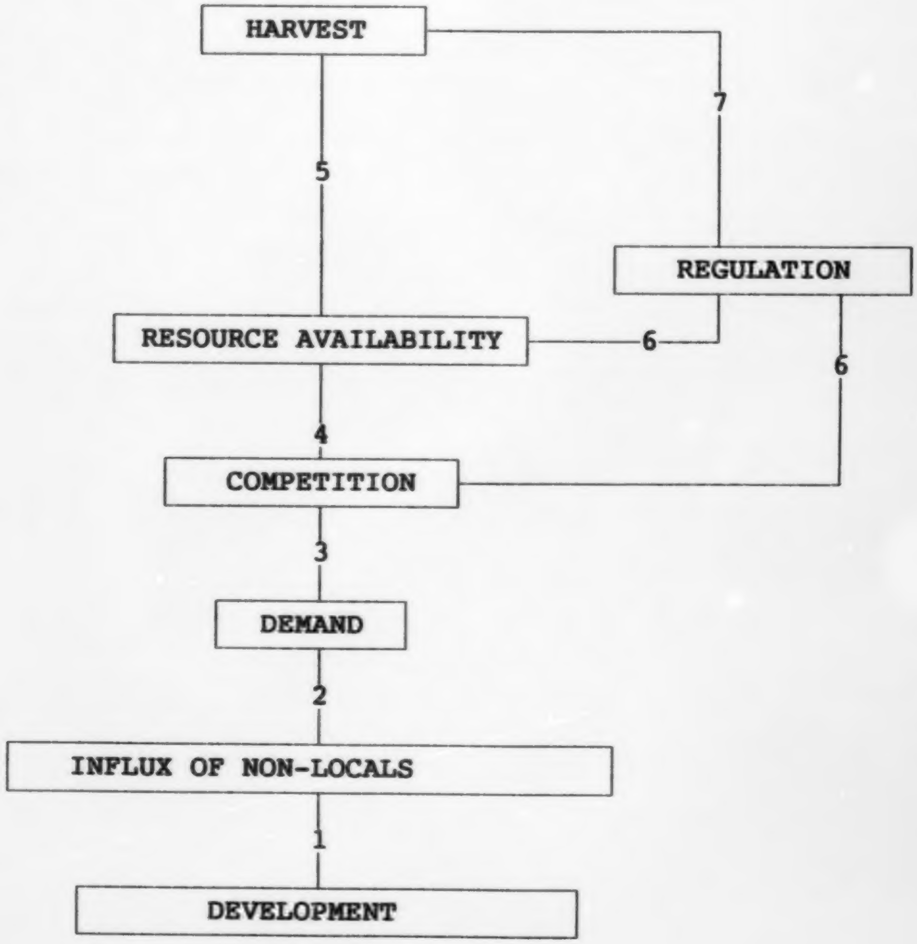
5 and 6 All levels of conflict resulting from the exclusion of harvesting from specified areas will be compensated.

RELEVANT PROJECTS

PROJECT	TITLE	PAGE
BEMP 2-3	A draft community-based Regional Land Use Plan for the Mackenzie Delta-Beaufort Sea region	139
BEMP 2-4	Inuvialuit harvest study	140
BEMP 13-6	Survey of fish users in Dene and Metis communities in and near the Mackenzie River watershed	213
MEMP 1-5	Native harvest surveys and statistics: a critique of their construction and use	281
MEMP 22-1	Harvest Study - South of Inuvialuit Settlement Region	386
MEMP 22-2	Data report based on information collected in 1981 during a survey of the domestic fishery in the Mackenzie Delta area, Northwest Territories	387
MEMP 22-3	Individual trapping - record summary	388

MEMP HYPOTHESIS NO. 25

INCREASES IN HUNTING BY NON-LOCALS WILL RESTRICT HARVESTS BY LOCAL NATIVES



LINKAGES

1. Development will result in influx of non-locals.

2. Influx of non-locals will result in increased demand for fish and wildlife.

3. Increased demand will result in increased effort and competition among harvesters.

4. Increased competition will result in decreased local resource abundance.

5. Increased harvesting effort by non-locals and/or decreased local resource availability will result in reduced local native harvests and/or reduced catch per unit effort.

6. Increased competition and/or decreased resource availability will lead to restrictions on local native harvests.

7. Regulation of harvest will restrict native harvests.

Summary of 1987/88, 1988/89, 1989/90 Resident Hunter Harvest Survey

BREAM PROJECT OVERVIEW NO. M25-1

PRINCIPAL INVESTIGATOR:	D. Grant-Francis
AFFILIATION:	Department of Renewable Resources, N.W.T.
FUNDING SOURCE:	Department of Renewable Resources, N.W.T.
EXPECTED COMPLETION DATE:	Annually and ongoing
RELEVANT HYPOTHESIS NO.:	MEMP 25

BRIEF PROJECT DESCRIPTION

This is an ongoing program that involves the collection and reporting of annual non-native resident hunter harvest data for selected species by community and region. Annual reports describe non-native resident hunter harvest of upland game birds and terrestrial mammals such as moose, woodland and barren-ground caribou.

Data are also collected on the location of harvest and some demographics of the harvester. Non-native resident hunters are licensed and regulated under a different system than native General Hunting Licence holders in the Northwest Territories. A non-native resident hunter must have resided in the Northwest Territories for a defined time period prior to the issue of the resident hunting license.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

Information presented in the annual reports is relevant to MEMP Hypothesis No. 25. Supplemented with other data, information on non-native resident hunter harvest can be useful in evaluating the effect of increases in non-local harvest on local native hunting.

OTHER RELEVANT PROJECTS

PROJECT	TITLE	PAGE
BEMP 2-4	Inuvialuit harvest study	140
MEMP 1-5	Native harvest surveys and statistics: a critique of their construction and use	281

5.3 RESEARCH RELEVANT TO NEW BREAM ISSUES

Investigations initiated after the EXXON VALDEZ and other recent oil spills was evaluated to provide the basis for developing new impact hypotheses that deal with catastrophic events. The following describes these studies and provides a discussion of their relevance to BREAM. A number of other relevant studies have been discussed in earlier sections in relation to their relevance to existing BEMP and MEMP hypotheses. It is emphasized that the projects reviewed here are by no means all of the recent investigations that are relevant to oil spills in this region.

Water Quality in Prince William Sound

BREAM PROJECT OVERVIEW NO. OS-1

PRINCIPAL INVESTIGATOR:	J.M. Neff
AFFILIATION:	Battelle Ocean Sciences
FUNDING SOURCE:	Exxon
COMPLETION DATE:	1990
RELEVANT HYPOTHESIS NO.:	Future impact hypotheses dealing with oil spills

BRIEF PROJECT DESCRIPTION

This report provides a summary of the results of several studies initiated after the EXXON VALDEZ spill to monitor the distribution and concentrations of petroleum hydrocarbons in the water column and in surface oil sheens, and relates these results to information from the scientific literature on the toxicity of crude oil to marine organisms living in the water column. The following overview has been taken from the report summary.

A water sampling program was initiated within six days after the crude oil spill to provide a basis for assessing the potential effects of spilled oil on the marine plants and animals (including species important to the commercial and subsistence fisheries) of the Sound and the adjacent Gulf of Alaska. Water samples were collected periodically through the spring, summer and fall months of 1989 at about 35 offshore locations, which were generally more than one-quarter mile from shore, as well as 26 locations within a few hundred yards of shore.

Measured concentrations of petroleum hydrocarbons in the water column in Prince William Sound have been consistently low since measurements began in March 1989. For a brief period in April, there was a measurable increase in the average concentrations of volatile aromatic hydrocarbons (VOAs) and polycyclic aromatic hydrocarbons (PAHs) in the upper water column. However, these elevated concentrations were well below the State of Alaska standard for aromatic hydrocarbons in marine waters. Throughout most of the open waters of Prince William Sound, concentrations of VOAs and PAHs returned to near background levels by the end of May and have remained there since. Concentrations of petroleum hydrocarbons in the water column of a few heavily oiled, sheltered bays remained slightly above background through June 1989.

Average concentrations of petroleum hydrocarbons measured in more than 2,300 water column samples (about 1,900 from offshore and 400 from nearshore) from Prince William Sound are well below (approximately 10 to 1000 times) concentrations that have been shown to be toxic or cause harmful sublethal effects in marine animals.

Oil sheens were sampled in several heavily-oiled bays and found to contain only traces of potentially toxic PAHs.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

Investigations initiated after the EXXON VALDEZ spill will provide information with which to develop and evaluate new impact hypotheses dealing with major spills and well blowouts in the Beaufort Sea. They will provide new and practical data on oil spill behaviour, cleanup, biodegradation and impacts on shoreline ecosystems; much of which may be relevant to chronic and catastrophic events in the Beaufort region. These potential events result in high degree of public concern and were clearly central issues in recent Environmental Impact Review Board (EIRB) public reviews conducted for Isserk (Esso) and Kulluk (Gulf) drilling proposals.

Wildlife and Wildlife Habitat Restoration and Compensation in the Event of an Oil Spill in the Beaufort Sea

BREAM PROJECT OVERVIEW NO. OS-2

PRINCIPLE INVESTIGATOR:	Beaufort Sea Steering Committee, Task Group 2 - Remediation and Restoration
AFFILIATION:	Various
FUNDING SOURCE:	Federal Government
COMPLETION DATE:	Complete
RELEVANT HYPOTHESIS NO.:	Future impact hypotheses dealing with oil spills

BRIEF PROJECT DESCRIPTION

Section 13 of the Inuvialuit Final Agreement (IFA) addresses the need for wildlife and wildlife habitat restoration in the context of wildlife compensation measures. Since the signing of the IFA, the full scope of Section 13 and the potential financial implications have been discussed but have never been dealt with in a comprehensive or systematic manner. This report addresses the need to create a generally acceptable procedure for developing and estimating the potential cost of a "worst-case" scenario as it relates to restoration and compensation. It also examines the issue of definitions for mitigative and remedial measures as specified in the IFA to reach some common understanding of the terms.

Two papers were prepared as background information for discussion during the workshop: (1) a review of wildlife restoration options and their applicability to the Beaufort Sea area (Cross *et al*. 1991); and (2) an analysis of compensation models and methodologies employed in the Beaufort region and elsewhere and recommendation on their applicability to the IFA (Davies and Olser 1990). The products of this work also include a synopsis of a workshop concerning wildlife compensation in the event of an oil spill in the Beaufort Sea (Davies and Osler 1991 - Part III of this report), and the development and implementation of a procedure to assess the practicability and costs of restoration that can be integrated with "worst case" oil spill impact assessment (Lawrence *et al*. 1991 - Part II of this report).

In the context of Section 13 of the IFA, the following definitions were proposed for mitigation and remediation to clearly define the differences in these terms.

Mitigation: *A priori* efforts to prevent or lessen potential adverse environmental effects that may occur.

Remediation: *A posteriori* efforts to correct or compensate for any adverse environmental effects that have occurred, and to prevent, lessen or compensate for any adverse environmental effects that may occur in the future as a result of the environmental damage.

It was concluded that while a number of environmental, social and scientific factors should influence the decision of "how clean is clean", the most important influence would be from the coastal residents whose harvest opportunities may be affected and from those parties who have a stake in compensation.

A procedure for estimating the potential costs of restoration in a "worst-case" scenario was developed and tested using valued wildlife species and elements of select worst-case scenarios. Information required to use this procedure in a project-specific application would include: a project-specific oil spill scenario, an assessment of the potential impacts on wildlife and habitat, and the predicted effectiveness of countermeasures and clean up.

A number of recommendations with respect to wildlife and habitat restoration, and compensation were made during the workshop and are presented in this report.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

It was concluded by Task Group 2 that biological research and monitoring is integral to predicting potential impacts and needs for practical restoration; evaluating impacts and effectiveness of restoration; and determining an end point for restoration and compensation. Through the framework of impact hypotheses, BREAM provides the technically-based process that is necessary in establishing priorities for research and monitoring.

REFERENCES

Cross, W.E., T.L. Hillis and R.A. Davis. 1991. Wildlife and wildlife habitat restoration in the event of an oil spill in the Beaufort Sea. A discussion paper. Unpubl. report for the Beaufort Sea Steering Committee Task Group 2. 32 p.

Davies, S.L. and C.F. Osler. 1990. Wildlife compensation in the event of an oil spill in the Beaufort Sea. A discussion paper. Unpubl. report for the Beaufort Sea Steering Committee Task Group 2. 24 p.

Davies, S.L. and C.F. Osler. 1991. Wildlife compensation in the event of an oil spill in the Beaufort Sea. Workshop synopsis. Unpubl. report for the Beaufort Sea Steering Committee Task Group 2. 18 p.

Lawrence, M., R. Hurst, W.E. Cross and J. Harper. 1991. Wildlife and wildlife habitat restoration in the event of an oil spill in the Beaufort Sea. Unpubl. report for the Beaufort Sea Steering Committee Task Group 2. 19 p.

Scientific Response Planning, Information Database Requirements and Environmental Assessment Methodology for an Oil Spill in the Beaufort Sea

BREAM PROJECT OVERVIEW NO. OS-3

PRINCIPLE INVESTIGATOR: Beaufort Sea Steering Committee, Task Group 4 - Research and Science
AFFILIATION: Various
FUNDING SOURCE: Federal Government
COMPLETION DATE: Complete
RELEVANT HYPOTHESIS NO.: Future impact hypotheses dealing with oil spills

BRIEF PROJECT DESCRIPTION

The Minister of Indian Affairs and Northern Development established the Beaufort Sea Steering Committee (BBSC) in September 1990 to assess the concerns of the Environmental Impact Review Board (EIRB) regarding preparedness for an oil spill in the Beaufort Sea. Seven Task Groups were formed to assist the BSSC. This work was managed by Task Group 4, which was charged with addressing three recommendations related to research and science. This report is presented in three parts corresponding to these recommendations.

(1)	Isserk Recommendation #5	Scientific (Research) Response Plan
(2)	Kulluk Recommendation #7	Environmental Assessment Methodology
(3)	Kulluk Recommendation #6	Information Database Requirements

The report includes: (1) the background leading to the EIRB recommendations; (2) the scope and framework for the work as determined by sections of the Inuvialuit Final Agreement and the EIRB recommendations; (3) a discussion section which uses of series of premises supported by a brief rationale and a consideration of the present status and needs; and (4) a section of conclusions and recommendations. A summary of these three report sections (which is taken largely from the executive summary) is presented below.

Part I of the report focusses on research that can take place only during and after an actual oil spill. Other spill-related research that is undertaken during "normal" field conditions or in laboratories is excluded from the scope of this exercise. It considers the components of a scientific (research) response under the elements of planning, implementation and operations with an emphasis on the planning phase. Project selection, financial authority and roles and responsibilities are discussed.

An approach to planning and implementing the scientific response to an oil spill is outlined. Although other approaches may be discovered and refined through further consideration, it was concluded by the Task Group that the scientific response must be a commitment, pre-planned to the extent possible, integrated within contingency plans, and assigned to a responsible manager of the spill response team.

Part II of the report addresses the scope of environmental assessment for developments within the Inuvialuit Settlement Region. The thrust and scope of the IFA review process is drawn from Section 13 of the IFA: wildlife, wildlife harvest and compensation for present and future harvest loss. In the offshore area, the Inuvialuit screening and review process is restricted to the purposes of wildlife compensation. The objectives of this assessment process are to recommend to the government authority whether or not the development should proceed and, if so, the terms and conditions (including mitigative and remedial measures).

It was concluded by the Task Group that the scope of the assessment review by the EIRB is prescribed under the IFA. This assessment review is not identical to either the EARP process or regulatory decision-making processes under other federal statutes. The assessment methodology used should be descriptively precise, semi-quantitative to the extent possible, explicit in terms of "impact" linkages and provide a logic or "audit" trail. It should follow a standardized approach for purposes of consistency and acceptance, but each review should be tailor made to the extent necessary for each development proposal. The impact assessment methodology developed by ESL Environmental Sciences Limited for Environment Canada and Public Works Canada and later adapted for Fisheries and Oceans Canada should be scrutinized as a potential methodology for EIRB reviews.

Part III of the report focusses on: (1) determining the status of the information database for the purposes of environmental assessment of oil spills and contingency planning (as defined by the EIRB Kulluk Recommendation #2 as countermeasures, clean up and wildlife protection); and (2) determining the sufficiency of existing databases to enable the EIRB to review offshore drilling proposals relative to its IFA mandate. It was concluded by the Task Group that an adequate information database needs to be available, as it is necessary for the purposes of environmental protection and assessment of oil spill scenarios and for contingency planning. However, the Beaufort Sea area has been under intense study by physical and biological scientists for nearly 20 years, and an extensive comprehensive information database does exist for the area. In the absence of a catastrophic oil spill offshore in the Beaufort Sea, many impact hypotheses will remain untested. This information, which can only be obtained following a major spill, forms the bulk of the "missing" information. Therefore, a research response should be developed to extent possible prior to a spill occurring to capitalize on any "spill of opportunity".

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

It was recommended by Task Group 4 that "candidates" for further research and monitoring should be further assessed and refined in a process that uses impact hypotheses, linkages and a more rigorous interpretation and determination of the adequacy of the existing information. While BEMP and MEMP were successful in evaluating research and monitoring needs in relation to potential impacts of routine aspects of development, major oil spills and other catastrophic events were explicitly outside the scope of these initiatives. The scope of BREAM is broader than its predecessors and includes consideration of catastrophic events.

Unlike BEMP and MEMP, which were directed only at research and monitoring issues, BREAM will include a major focus on environmental assessment. This acknowledges some of the information shortcomings identified during the recent EIRB reviews, as well as the continuing need to evaluate the potential impacts of revised hydrocarbons development and transportation scenarios.

Valdez Oil Spill Technology, 1989 Operations

BREAM PROJECT OVERVIEW NO. OS-4

PRINCIPLE INVESTIGATOR:	Anonymous
AFFILIATION:	Exxon Corporation
FUNDING SOURCE:	Exxon Corporation
COMPLETION DATE:	Complete
RELEVANT HYPOTHESIS NO.:	Future impact hypotheses dealing with oil spills

BRIEF PROJECT OVERVIEW

This document summarizes and assesses the technology used in responding to the EXXON VALDEZ oil spill. Assessments were conducted in three broad areas of spill response technology: (1) containment and recovery of oil floating on the water; (2) treatment of oiled shoreline; and (3) marine operations and logistics needed to support the spill response.

In assessing the effectiveness of oil containment and recovery, key observations are made on mobilization of equipment, oil tracking and trajectory forecasting, oil containment booms, free-oil recovery on open water, skimmer off-loading, and shoreline oil recovery. Key findings related to shoreline treatment include shoreline assessment and mapping, treatment methods, and bioremediation. Activities to support the offshore and shoreline operations are also discussed. These include: marine operations, logistics, safety and health, waste management and demobilization.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL MONITORING AND ASSESSMENT PROJECT

The results of this study will be useful in developing and evaluating new impact hypotheses to deal with major oil spills and well blowouts in the Beaufort Sea. The study provides new and practical information on the effectiveness of oil spill response technology, much of which may be relevant to catastrophic events in the Beaufort region.

The Role of Large-scale Under Ice Topography in Separating Estuary and Ocean on an Arctic Shelf (NOGAP B.6-2)

BREAM PROJECT OVERVIEW NO. OS-5

PRINCIPAL INVESTIGATORS: R.W. Macdonald and E. Carmack
AFFILIATION: Institute of Ocean Sciences, Department of Fisheries and Oceans
FUNDING: NOGAP and DFO
COMPLETION DATE: Complete
RELEVANT HYPOTHESIS NO: Future impact hypotheses deal with oil spills

BRIEF PROJECT DESCRIPTION

This study is part of a broad-based study (Beaufort Sea Oceanography - NOGAP B.6), which is investigating the hydrocarbon geochemistry, primary productivity and oceanographic processes of the Beaufort Sea shelf.

Based on measurements of salinity and $\delta 0^{18}$ in water and ice along transects seaward from the Tuktoyaktuk Peninsula to the shelf break, an analysis was made of the sources of water on the shelf in the winter. The analysis concludes that an underwater ice dam at the outer edge of the landfast ice produced by ridging effectively splits the Mackenzie estuary in winter. This split is critical to the process of the exchange of shelf waters with the Arctic Ocean during winter. On the nearshore side of the inverted ice dam, fresh water accumulates over winter forming a corridor for migration and for transport of materials including fresh water. Sufficient meteoric fresh water is supplied to this area to allow ice growth without depleting the standing stock of fresh water in the water column. The flushing time for the impounded fresh water is given by its volume divided by the Mackenzie inflow rate. Taking the dimensions of the nearshore corridor to the volume of 30 km x 300 km, and the average freshwater standing stock to be 2.5 m, then the volume of fresh water stored behind the dam is about 2×10^{10} m^3; taking the Mackenzie River flow in winter to be 3.5×10^3 m^3 s^{-1} yields a flushing time of order 2-3 months. Hence, the river supplies more than enough to maintain freshwater standing stocks in the near shore over winter.

On the seaward side of the ice dam, ice removes fresh water from the water column, thereby increasing its density. The recurrent polynya that forms in the deformation zone during winter accelerates the process, causing salinity isopleths to plunge and dense water to sink and spread laterally. The overwhelming importance of ice topography to the above process is best seen by contrast with a region where the ice topography is relatively flat (e.g., Hudson Bay). There, the ice facilitates the spread of the plume to areas farther offshore than in summer, and the under-ice plume area tends to be larger.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

Although not dealing specifically with contaminant distribution, this work provides a valuable insight into water properties over the shelf in the winter and will be helpful in predicting the fate of spilled oil trapped under the ice in winter.

REFERENCE

Macdonald, R.W. and E. Carmack. 1991. The role of large-scale under ice topography in separating estuary and ocean on an Arctic shelf. Atmosphere-Ocean 29 (1):37-52.

Primary Productivity on the Beaufort Sea Shelf (NOGAP B.6-4)

BREAM PROJECT OVERVIEW NO. OS-6

PRINCIPAL INVESTIGATORS:	R.W. Macdonald and E. Carmack
AFFILIATION:	Institute of Ocean Sciences, Department of Fisheries and Oceans
FUNDING SOURCE:	NOGAP and DFO
EXPECTED COMPLETION DATE:	March 1992
RELEVANT HYPOTHESIS NO:	Future impact hypotheses dealing with oil spills

BRIEF PROJECT DESCRIPTION

This study is part of a broad-based study (Beaufort Sea Oceanography - NOGAP B.6), which is investigating the hydrocarbon geochemistry, primary productivity and oceanographic processes of the Beaufort Sea shelf.

Measurements of nutrients, C^{14}, phytoplankton and particle fluxes and composition have been taken along transects across the Beaufort Sea shelf in an effort to understand the levels of primary productivity on the shelf in relation to water properties. The study will investigate the spatial and time-dependant variability of primary productivity on an annual basis.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROGRAM

The project has relevance to catastrophic oil spill scenarios by providing information on locations and times when productivity will be sensitive to perturbation by an oil spill event. Because primary productivity is at the base of the food chain, this will be important to the distribution and abundance of all marine fish and mammal species.

Studies on the Physical and Chemical Behaviour of Oil and Dispersant Mixtures

BREAM PROJECT OVERVIEW NO. OS-7

PRINCIPAL INVESTIGATORS:	M. Fingas, I. Bier, M. Bobra, and S. Callaghan
AFFILIATION:	Environment Canada, Emergencies Science Division
FUNDING SOURCE:	Environment Canada, and US Minerals Management Service
COMPLETION DATE:	Complete
RELEVANT HYPOTHESIS NO:	Future impact hypotheses dealing with oil spills

BRIEF PROJECT DESCRIPTION

Laboratory studies on dispersant effectiveness were conducted to assess the effects of several variables, and to determine the action mechanisms of dispersants. The variables examined were temperature, salinity, and dispersant quantity. Dispersant effectiveness was measured as a function of the five oil bulk components: asphaltenes, aromatics, polar compounds, saturate compounds, and waxes.

The effect of water temperature variation is logarithmically correlated with dispersant effectiveness. With regard to salinity, effectiveness is at a peak when salinity is about 40‰ of typical commercial dispersant formulations and falls to nearly 0 as salinity rises from 40 to 80‰. This behaviour is explained by the necessity for a certain level of ionic strength to stabilize the surfactant between the oil droplet and the water. Dispersant quantity was also found to be an important factor. Dispersant-to-oil ratios greater than 1:40 or 1:60 result in very low dispersant effectiveness. Effectiveness is logarithmic with respect to dispersant-to-oil ratio.

Dispersion experiments were conducted to investigate the effects of oil composition. Dispersant effectiveness is positively and strongly correlated with the saturate concentration in the oil and is negatively correlated with aromatic, asphaltene, and polar compound contents of the oil. Dispersant effectiveness is only weakly correlated with oil viscosity. Dispersant effectiveness is primarily limited by oil composition.

Four Beaufort Sea oils (Amauligak, Issungnak, Adgo and Atkinson) were among the 24 oils studied. Dispersant effectiveness for Corexil ranged from 39% for Atkinson to 66% for Issungnak crude.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROGRAM

This study provides valuable information on the effectiveness of dispersants as a function of temperature and salinity. Both factors vary widely on the Beaufort Sea shelf. A usable finding is the low effectiveness of dispersants at low salinity, which is an important feature of much of the Beaufort Sea shelf surface water in the open water season.

REFERENCE

Fingas, M., I. Bier, M. Bobra and S. Callaghan. 1991. Studies on the physical and chemical behaviour of oil and dispersant mixtures. *In:* Proceedings of the 1991 International Oil Spill Conference, San Diego. pp. 419-426.

The Fate of Diesel Fuel Spilled by the BAHIA PARIASO in Arthur Harbour, Antarctica

BREAM PROJECT OVERVIEW NO. OS-8

PRINCIPAL INVESTIGATORS: M. Kennicutt II, S. Sweet, W. Fraser, M. Culver, and W. Stockton
AFFILIATIONS: College of Geosciences, Texas A&M University, Point Reyes Bird Observatory, Institute of Marine Sciences, University of California, Santa Cruz
FUNDING SOURCE: NSF and NOAA
COMPLETION DATE: Complete
RELEVANT HYPOTHESIS NO: Future impact hypotheses dealing with oil spills

BRIEF PROJECT DESCRIPTION

The BAHIA PARIASO spilled an estimated 600,000 litres of refined product (diesel fuel arctic (DFA) into Arthur Harbour, Antarctica, in January 1989. Water, organisms and sediments within a two mile radius of the wreck were contaminated to various degrees for at least one year after the spill. The DFA contained about one percent toxic aromatic hydrocarbons, including naphthalenes, fluorenes, and phenathrenes. Intertidal areas were most directly affected, but all components of the harbour ecosystem were contaminated during the first few weeks of the spill. DFA was detected in tissues from birds, limpets, macroalgae, clams and bottom feeding fish, as well as water and sediments collected over a six-week period. During the most intense phase of the spill, total polynuclear aromatic hydrocarbons reached levels as high as 125,147 and 1,723 ppb (dry weight) in limpet tissues and sediments, respectively. The high-energy environment, the relatively small volume of material released, and the volatility of the refined product helped to limit toxic effects over time and space. Most of the spilled material evaporated, and the rest was diluted and swept from the area by winds and currents. Sedimentation, biological uptake, microbial oxidation, and photo-oxidation accounted for removal of only a minor portion of the spill.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROGRAM

This study has direct relevance to similar spills in the Beaufort Sea region because of similarities in water and air temperatures and latitude. The results provide an indication of the possible extent and likely degree of contamination that might be expected for a spill of a similar size in Arctic waters.

REFERENCE

M. Kennicutt II, S. Sweet, W. Fraser, M. Culver and W. Stockton. 1991. The fate of Diesel Fuel spilled by the BAHIA PARIASCO in Arthur Harbour, Antarctica. *In:* Proceedings of the 1991 International Oil Spill Conference, San Diego. pp. 493-500.

Water-in-oil Emulsification: A Physicochemical Study

BREAM PROJECT OVERVIEW NO. OS-9

PRINCIPAL INVESTIGATOR:	M. Bobra
AFFILIATION:	Consultchem Ltd.
FUNDING SOURCE:	Environment Canada and US Minerals Management Service
COMPLETION DATE:	Complete
RELEVANT HYPOTHESIS NO:	Future impact hypotheses dealing with oil spills

BRIEF PROJECT DESCRIPTION

This study examined the basic mechanism by which asphaltenes, resins and waxes stabilize water-in-oil emulsions. Laboratory experiments were conducted on the emulsification behaviour of model oils that contained alkane and aromatic components and emulsifying agents. Results clearly demonstrate the importance that the physical state of an emulsifying agent has on its ability to stabilize emulsions. It was found that, to be effective, emulsifiers, asphaltenes, resins, and waxes must be in the form of finely divided, submicron particles. In addition, it was shown that the solvency strength of an oil, which is determined by its alkane and aromatic components, controls the solubility/precipitation behaviour of these emulsifiers. The chemical composition of the oil determines not only the amount and size of precipitated particles, but also the composition and wetting properties of the particles. All these factors were shown to influence emulsification.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROGRAM

The study results will be of value in any oil spill scenario in the prediction of the stability and fate of water-in-oil emulsions based on a knowledge of the oil and water properties.

REFERENCE

Bobra, M. 1991. Water-In-Emulsion; A physicochemical study. *In:* Proceedings of the 1991 Oil Spill Conference, San Diego. pp. 483-488.

The NESTUCCA Oil Spill: Preliminary Evaluation of Impacts on the West Coast of Vancouver Island

BREAM PROJECT OVERVIEW NO. OS-10

PRINCIPAL INVESTIGATORS:	W. Duval, S. Hopkinson, R. Olmsted, and R. Kashino
AFFILIATION:	ESL Environmental Sciences Limited
FUNDING SOURCE:	Environment Canada and B.C. Ministry of Environment
COMPLETION DATE:	Complete
RELEVANT HYPOTHESIS NO:	Future impact hypotheses dealing with oil spills

BRIEF PROJECT DESCRIPTION

This report discusses the initial impacts reported following the 23 December 1988 collision between the fuel barge NESTUCCA and its tender tug OCEAN SERVICE off the mouth of Grays Harbour in the State of Washington. An unknown proportion of the Bunker C oil from the barge moved northward to strand on shorelines along the west coast of Vancouver Island. While several longer term studies were initiated by the federal and provincial governments, this report describes effects of the event on the biophysical environment and resource use documented over the following four months. It also discusses the movements and fate of oil on the B.C. coast and includes oil time-series maps, native harvest area and resource distribution maps prepared with a Geographic Information System (GIS).

The most apparent initial impact of the NESTUCCA spill was the death of about 12,500 seabirds in British Columbia and Washington, although known or anticipated damage to other biological resources is also described in the report. This included mortality of intertidal algae and other vegetation, extensive contamination of salt-marsh habitat, contamination of crabs by oil, death of one sea otter and contamination of other marine mammals (seals, sea lions and elephant seals), and mortality of some intertidal invertebrate species. There were documented impacts of the event by April 1989 on important salmon or herring populations.

No cultured oyster stocks were reported to be contaminated with oil, but there was a temporary impact on shellfish farmers due to short-term precautionary closures of some areas for shellfish harvest. There was no apparent effect on the salmon farms on the west coast of Vancouver Island.

RELATIONSHIP AND RELEVANCE TO THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROGRAM

The results of this and other longer-term studies initiated after the NESTUCCA spill will be of some value in evaluation of future BREAM impact hypotheses dealing with major oil spills.

REFERENCE

Duval, W., S. Hopkinson, R. Olmsted and R. Kashino. 1989. The NESTUCCA oil spill: preliminary evaluation of impacts on the west coast of Vancouver Island. Prep. by ESL Environmental Sciences Limited for Environment Canada and B.C. Ministry of Environment. 62 p. + appendices and maps.

OTHER RELEVANT PROJECTS

PROJECT	TITLE	PAGE
BEMP 2-5	Environmental atlas for Beaufort Sea oil spill response	141
BEMP 10-2	Immediate impact of the EXXON VALDEZ oil spill on marine birds	177
BEMP 10-6	Wildlife and wildlife habitat restoration in the event of an oil spill in the Beaufort Sea	182
BEMP 10-14	NESTUCCA oil spill: impact assessment of avian populations and habitat	194
BEMP 10-15	Distribution and abundance of waterbirds in Barkley Sound and the Long Beach/Tofino/Grice Bay area in spring 1989 following the NESTUCCA oil spill	195
BEMP 10-16	Foraging activity of migrating Brant at Stubbs Island in April 1989 following the NESTUCCA oil spill	195
BEMP 10-17	British Columbia seabird colony inventory: Report #4 - Scott Islands. Census results from 1982 to 1989 with reference to the NESTUCCA oil spill	196
BEMP 10-18	Attendance patterns, hatching chronology and breeding population of common murres on Triangle Island, British Columbia, following the NESTUCCA oil spill	197
BEMP 13-5	Beaufort Sea oil spill modelling and contingency planning	211
BEMP 13-7	Geochemistry and fluxes of hydrocarbons to the Beaufort Sea shelf	214

OTHER RELEVANT PROJECTS (Continued)

PROJECT	TITLE	PAGE
BEMP 13-8	The distribution of hydrocarbons across the Beaufort Sea shelf	216
BEMP 13-10	The flux of suspended particulates, petroleum-related hydrocarbons, trace metals and nutrients from the Mackenzie River during the winter season: A pilot study of the East Channel	218
BEMP 13-14	Condensate effects on commercial species	225
BEMP 13-15	The evaluation and selection of an analytical method to detect a hydrocarbon taint in fish	227
BEMP 13-16	Tainting/contamination potential of weathered oil particulates for commercially-important fish species	228